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The guidelines are a revision of the previous guidelines, "Pretreatment of Pollutants Introduced Into Publicly Owned Treatment Works." Contained in this revision is additional technical information on pollutants which may interfere with or pass through publicly owned treatment works. Also, guidance is presented to assist State and local governments in developing their own pretreatment programs to comply with NPDES permit conditions.

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JANUARY 1977

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VOLUME I

FEDERAL GUIDELINES

STATE AND LOCAL PRETREATMENT PROGRAMS

JANUARY 1977

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF WATER PROGRAM OPERATIONS
MUNICIPAL CONSTRUCTION DIVISION
WASHINGTON, D.C. 20460

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U.S. ENVIRONMENTAL PROTECTION AGENCY

FOREWORD

In response to the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500), this country has undertaken an unprecedented program of cleaning up our Nation's waters. There will be a substantial investment by Federal, State, and local governments as well as by private industry in treatment works to achieve the goals of the Act. It is important that this investment in publicly owned treatment works (POTW's) be protected from damage and from interference with proper operation, and that receiving waters be protected from pollutants which may pass through the POTW.

These guidelines were developed by the Environmental Protection Agency in accordance with Section 304(f) of the Act for the purpose of assisting States and municipalities in carrying out programs under Section 402, including NPDES permit requirements. It is important to note the clear requirements in the Act that there be both national pretreatment standards, Federally enforceable, and pretreatment guidelines to assist States and municipalities in developing local pretreatment requirements. The Environmental Protection Agency encourages the establishment of local pretreatment requirements, tailored to local conditions.

The guidelines are a revision of the previous guidelines, "Pretreatment of Pollutants Introduced Into Publicly Owned Treatment Works." Contained in this revision is additional technical information on pollutants which may interfere with or pass through publicly owned treatment works. Also, guidance is presented to assist State and local governments in developing their own pretreatment programs to comply with NPDES permit conditions. The guidelines are the result of extensive reviews and numerous field trips and discussions with EPA Regional Offices, industry, city, regional, State and interstate agencies. We are extremely grateful for the cooperation of those who assisted in the preparation of the guidelines.

/s/ John Quarles
The Administrator
Acting

DEC 22 1976

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SECTION A

INTRODUCTION

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SECTION A
INTRODUCTION

Purpose

These guidelines are established to assist municipalities, States, Federal agencies, and others in developing requirements for the pretreatment of wastewaters which are introduced into publicly owned treatment works (POTW's). This document is a revision of an earlier publication dated October 1973, and presents a compilation of technical and administrative information relative to pretreatment and the control of industrial wastewaters in publicly owned systems. Information contained herein is designed to provide the operators of POTW systems with a sound basis for determining the impact of non-residential wastewaters, as well as appropriate approaches for controlling pollutants from these sources.

Additionally, this document provides guidance helpful in complying with those special conditions of the National Pollutant Discharge Elimination System (NPDES) permits issued to POTW's that relate to non-residential wastewaters. Technical aspects, including data on pollutants which may interfere with the operation of POTW's, and the removal of pollutants in treatment facilities are covered in detail. Legal considerations encompassing methods for establishing pollutant limitations and a recommended ordinance for industrial use of sewers are also addressed. Additionally, information on the management and monitoring requirements of an industrial wastewater control program and summaries of the wastewater characteristics and pretreatment information for major industrial categories are included.

In summary, this document provides guidance to State and local governments concerned with implementing pretreatment programs. The guidelines are subject to modification as a result of EPA review of its policy in pretreatment.

Background

Up until 1972, the emphasis in Federal legislation had been oriented toward water quality standards. With the enactment of the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500) a number of fundamental changes in the approach to achieving clean water were instituted. One of the most significant changes was from an emphasis on the ambient quality of streams to direct control of effluents through the establishment of regulations and standards which form a basis for the issuance of discharge permits. In addition, the 1972 Amendments required the development of pretreatment guidelines and standards to provide a uniform approach to the control of industrial pollutants introduced into POTW's.

Public Law 92-500 established a national system for preventing, reducing, and eventually eliminating water pollution. By the creation of the National Pollutant Discharge Elimination System (NPDES), the Act has required that all point sources (including POTW's) obtain a permit for the discharge of wastewaters to the navigable waters of the United States.

The Act further requires that as a minimum intermediate objective, all point sources other than POTW's treat their wastewaters by the application of the best practicable control technology. Subsequently, the minimum requirement for industrial wastewaters would be the application of best available treatment technology. For POTW's the initial objective is secondary treatment, as outlined in "Secondary Treatment Information" promulgated by the Environmental Protection Agency on August 17, 1973 (Appendix 2).

As an additional measure designed to protect the quality of navigable waters, Public Law 92-500 also contains provisions that require regulating the pretreatment of nondomestic wastewaters contributed to POTW's. In the following section, those portions of the Act that pertain to pretreatment, including the section providing authority for the development of this document are discussed.

Authority

Under Title III of the Act, "Standards and Enforcement," several sections are included that specifically refer to the pretreatment of pollutants introduced into POTW's. Authority for development and revision of this guidelines document is contained in Section 304(f) which states:

> "For the purpose of assisting States in carrying out programs under section 402 of this Act, the Administrator shall publish..... and review at least annually thereafter and if appropriate, revise guidelines for pretreatment of pollutants which he determines are not susceptible to treatment by publicly owned treatment works. Guidelines under this subsection shall be established to control and prevent the discharge into the navigable waters, the contiguous zone, or the ocean (either directly or through publicly owned treatment works) of any pollutant which interferes with, passes through, or otherwise is incompatible with such works."

These guidelines should not be confused with pretreatment standards for both existing and new sources, promulgated under the authority of Sections 307(b) and 307(c) respectively. Section 307(b) is directed toward existing sources, and states:

> "The Administrator shall.....publish proposed regulations establishing pretreatment standards for introduction of pollutants into treatment works.....which are publicly owned for those pollutants which are determined not to be susceptible to treatment by such treatment works or which would interfere with the operation of such treatment works."

Under the authority of this Section, the EPA promulgated on November 8, 1973, general pretreatment standards, which are included in Appendix 1 of this document. These pretreatment standards set forth rules and regulations designed to protect POTW's from the possible harmful effects of industrial wastewaters introduced into such systems. In addition to the general pretreatment standards, this section also provides authority for the development of pretreatment standards for specific major industrial categories of non-residential contributors. Similarly, Section 307(c) authorizes the promulgation of pretreatment performance standards for new sources.

The distinction between pretreatment standards and pretreatment guidelines must be emphasized. This document, as indicated, is strictly advisory, for the purpose of providing pretreatment assistance to interested parties. As such, these guidelines only recommend approaches to developing pretreatment policy. In contrast, the pretreatment standards as promulgated under Section 307 of the Act, represent rules and regulations which are enforceable by the Federal government.

Federal Pretreatment Standards

EPA has issued general standards for pretreatment of pollutants introduced into POTW's (Appendix 1). Subsequent to the promulgation of pretreatment standards on November 8, 1973, the Agency has proposed and promulgated numerous pretreatment standards relative to specific industry category wastewater discharges for both existing sources and new sources. As a result of these proposed and promulgated regulations, the Agency has received numerous indications that its pretreatment procedures, both for the establishment of and for the enforcement of pretreatment standards, and the pretreatment standards themselves were not clearly understood by many segments of the general public. For this reason, the Agency has decided to clarify and simplify the existing pretreatment standards. This will be accomplished by proposing new general pretreatment regulations to replace the existing standards contained in Appendix 1. It is anticipated that the proposed standards will be published in the Federal Register in the near future. At that time the proposed regulation and an appropriate discussion will be incorporated in these guidelines.

The pretreatment standards are intended to be national in scope. In many cases, it will be necessary for a State or a municipality to supplement the Federal standards with additional pretreatment requirements which take into account local conditions. Factors such as stringent water quality standards reflected in the POTW's NPDES permit or characteristics of the treatment process may necessitate more restrictive pretreatment requirements in specific instances. The Federal pretreatment standards do not preclude municipalities and States from establishing pretreatment standards of their own, not in conflict with any Federal pretreatment standard, as stated in Section 307(b)(4) of P.L.92-500. State or local standards may be necessary to control types, flows, concentration and variability of industrial and commercial discharges into municipal treatment works.

There may be specific situations when the Federal pretreatment standards will not be sufficient to protect the operation of the publicly owned treatment works. This might be the case when the quantity of a pollutant not susceptible to treatment in a POTW, introduced by a major contributing industry, would result in a concentration of the pollutant in the influent to the treatment works which would inhibit the performance of the treatment process. In such a case, the municipality would have to supplement the Federal standards. Additionally, State or local pretreatment standards may be necessary for pollutants susceptible to treatment in a POTW. Pretreatment of wastewaters containing susceptible pollutants may be necessary in the form of spill protection or flow equalization in order to ensure compliance with the Federal pretreatment standards and permitted effluent limitations.

EPA has been, and is currently in the process of promulgating rules and regulations setting forth effluent limitations guidelines and standards of performance for the treatment of specific industrial wastes discharged to navigable waters. In pursuit of this goal, EPA has categorized wastewater producing commercial activities, and has, on an industry by industry basis, published effluent standards in the Federal Register (40 CFR 400 series). In each of these rules and regulations for specific major industries, pretreatment standards are either proposed or promulgated in addition to the requirements for wastewaters which are directly discharged. To date, pretreatment standards for new sources have generally been established in final form, while final rules and regulations for the pretreatment of existing sources have only been partially promulgated. Pretreatment standards for existing sources within fifteen major industrial categories were promulgated on February 11, 1975 (Appendix 1), with approximately twenty additional industrial pretreatment standards still pending. The pretreatment standards published for the first fifteen industries do not establish limitations on pollutants contributed to municipal systems because the pollutants from these industries are usually susceptible to treatment in a POTW. In other words, for the first fifteen industrial categories, there is no specific numerical pretreatment requirement at the Federal level. However, there are general prohibitions provided in the pretreatment standards contained in Appendix 1.

On the other hand, the pretreatment standards promulgated for new sources in various industrial categories generally contain limitations on the level of specific pollutants allowable in the wastewater discharged to POTW's. The nature of the pretreatment standards to be established for the remaining major industrial categories is unknown at this time. When issued, the information in these remaining standards will be useful to local governments in determining exact pretreatment requirements for the industries in question. For new sources, pretreatment standards have been established for a number of major industries and have been published in the Federal Register.

Planning Agencies & Pretreatment Responsibility

Section 208(b)(2)(C)(iii) provides for:

> The establishment of a regulatory program to assure that any industrial or commercial wastes discharged into any treatment works in such areas meet applicable pretreatment requirements.

Accordingly, a Water Quality Management Planning (208) Agency will play a major role in ensuring that all industrial wastes discharged into POTW's comply with Federal pretreatment standards promulgated under Section 307 of the Act. Additionally, such a planning agency will assist municipalities in establishing pretreatment programs.

In many cases as a result of water quality requirements or other factors specific to a plant or its NPDES permit, it will be necessary for the municipality to establish pretreatment requirements more stringent than the Federal standards. The planning agency will assist the municipality in developing these pretreatment requirements and ensuring their compliance.

Industrial users will be required to meet both Federal and applicable State and local pretreatment requirements. These requirements will be evaluated within the Water Quality Management process in order to ensure that effluent limitations for the POTW designated in its NPDES permit can be met. Similarly, facilities plans will be reviewed and pretreatment will be an issue in these reviews. In practice, (208) planning agencies will work closely with municipalities, giving expert advice on how to write pretreatment requirements for inclusion into the municipal ordinance.

Effluent Limitations for POTW's

As a result of the fundamental changes instituted by Public Law 92-500, POTW's are now required to obtain permits for their discharges and to meet certain minimum effluent standards. Both POTW permits and effluent standards have a direct bearing on the control of industrial pollutants that must be undertaken within a particular system.

Since most POTW's discharge their effluents to navigable waters, the Act requires that effluent limiting regulations be promulgated. As indicated, EPA has published in the Federal Register rules and regulations governing POTW discharges entitled "Secondary Treatment Information," (Appendix 2). These regulations set forth specific concentration limits to be achieved by secondary wastewater treatment facilities. Limits are placed on permissible discharge concentrations (or removal efficiencies) for BOD, suspended solids, and fecal coliform bacteria. Additionally, an acceptable pH range for secondary POTW effluents is set. The pollutants limited in the regulation are generally susceptible to treatment in POTW's. As a consequence, industrial pollutants only become important with regard to secondary treatment standards when the contribution causes these pollutant discharge limitations to be exceeded.

In many instances, State or local water quality standards require a degree of treatment greater than that required to meet the secondary treatment regulations, such as more stringent BOD or suspended solids requirements.

Additionally, water quality standards often exist for pollutants other than those regulated in the secondary treatment standards, such as phosphorous, nitrogen compounds, metals, etc. Treatment requirements necessary to meet water quality standards are normally incorporated into the NPDES permit. Consequently, control of applicable industrial pollutants can be extremely important in helping the municipality meet its NPDES permit requirements.

Procedures developed under Section 402 of the Act provide details for implementation of the NPDES permit program. Under the program, all point sources, including POTW's, must obtain a permit to discharge to navigable waters of the United States. NPDES permits are not required for industrial sources contributing to POTW's, but many limitations placed on a POTW, beyond standard secondary treatment, are aimed at controlling the effects of non-domestic wastewaters.

The NPDES permit has several impacts on State or local pretreatment policy. First, as a part of the permit application, the permittee must obtain preliminary information on the activities and wastewater characteristics of major industrial contributors within the collection system. Based on this information, effluent limitations for pollutants not susceptible to treatment in a POTW may be individually established by the permitting agency.

Secondly, under the Federal NPDES permit regulations (40CFR126) the permitee is required to provide notice to the Regional Administrator of the following:

(i) Any new introduction of pollutants into such treatment works from a source which would be a new source as defined in Section 306 of the Act if such source were discharging pollutants;

(ii) Any new introduction of pollutants which exceeds 10,000 gallons on any one day into such treatment works from a source which would be subject to Section 301 of the Act if such source were discharging pollutants; and

(iii) Any substantial change in volume or character of pollutants being introduced into such treatment works by a source introducing pollutants into such works at the time of issuance of the permit.

This notice must include information on the quantity and quality of wastewater introduced by the new source into the publicly owned treatment works, and any anticipated impact on the effluent discharged from such works.

In addition to effluent limitations, the permit sets forth special conditions that pertain to pretreatment activities. Municipalities are considered the first line of defense for Federal pretreatment programs. For this reason, they are encouraged to enact an ordinance giving them the power to enforce Federal pretreatment standards as well as State and local standards "not in conflict" with Federal pretreatment standards. Areawide planning agencies will also play an important role in both ordinance development by municipalities as well as ensuring that pretreatment requirements accomplish the goals of the Act. In an efficient POTW system, a properly designed ordinance acts as the impetus for a responsible approach to control and pretreatment of industrial pollutants. Guidance is provided in this document to aid in the development of a municipal ordinance for industrial use of publicly owned sewers.

Organization of Guidelines

These guidelines are presented in three volumes. Volume I contains the main body of the guidelines, and Volumes II and III contain appendices furnishing the backup data to various sections of the document. Volume III is devoted to Appendix 8, containing pretreatment information for major industrial source categories compiled from published and unpublished Effluent Limitation Guidelines Development Documents.

The main body of the guidelines is composed of six major sections. The first four sections provide the essential information necessary to establish and administer an industrial pollutant control program. Specific aspects discussed include organization, financial considerations, policy and public relations in Section B, legal aspects in Section C and monitoring in Section D. The legal aspects consist primarily of considerations related to an ordinance for industrial use of publicly owned sewerage facilities. A recommended ordinance is contained in Section C of the first volume.

One of the prime considerations in the development of a workable ordinance is the establishment of limitations for specific pollutants contained in industrial discharges to publicly owned sewerage systems. Administrative considerations for setting such limits are discussed in Section C. The technical information necessary to establish limits in a particular system is contained in Sections E and F of Volume I, Appendices 5 and 6 of Volume II, and Appendix 8 of Volume III. Section E and Appendix 5 present technical data on the interference and inhibition characteristics of pollutants contained in industrial discharges. The data presented includes information on major organic and inorganic constituents, explosive and corrosive wastes and excessive discharges. Section F and Appendix 6 provide the results of a survey to determine the removal or pass through characteristics of various pollutants in POTW's. Appendix 8 is a compilation of information on major industries, with emphasis on the typical wastewater characteristics of plants within the subcategories established for each industry.

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SECTION B
MANAGEMENT OF A CONTROL PROGRAM

Purpose

The objective of an industrial pollutant control program is to assure continuity of treatment, provide physical protection of treatment facilities, and prevent the discharge of pollutants from the treatment facilities which would be in violation of NPDES permit conditions and other regulatory requirements. In order to achieve these objectives, POTW operators must develop programs which provide a data base for establishing local requirements and which after the requirements have been established, form a framework for administering these requirements. The purpose of this section is to discuss various aspects relating to the management of an industrial pollutant control program.

The scope of such a program depends to a large degree on a number of factors. Of prime importance is the size of the sewerage system and the number and type of industries utilizing the system. Other significant elements include the type of treatment facility, the water quality standards applicable to the POTW and the provisions of the plant's NPDES permit.

In this section, management approaches are discussed on three levels, for large, medium, and small systems, referring in general to systems with average dry weather flows in excess of 100 mgd, between 10 and 100 mgd, and less than 10 mgd. However, a system with a heavy industrial contribution, but an average flow of under 10 mgd may opt for a more extensive program, whereas a system with an average flow in excess of 10 mgd but only limited industrial contribution may adopt a less comprehensive program. Thus the categorization by size is provided as a general guideline only, and should be considered flexible depending upon the needs of a particular system. In the case of small and intermediate size systems, the 208 areawide planning agency can provide valuable assistance to a POTW in development of a viable control program. The degree of industrialization in a community and the type of industrial facilities contributing to the system, are major factors in determining the requirements of an industrial pollutant control program for a given POTW.

Historically, municipalities and authorities that have developed effective programs to control industrial pollutants have generally been motivated by several factors. The most effective industrial pollutant control programs have generally been instituted where the need to protect treatment facilities, plant operation or receiving waters has been apparent. In those cases, the motivating force toward a control program was either frequent or serious plant upsets or the requirement of meeting stringent water quality standards. Also, many POTW's have established industrial programs primarily as a revenue producing mechanism through the use of user charges. User charges have been applied not only to flow and organic loading, but in many instances user charges have been imposed upon incompatible pollutants as well.

For many POTW's interest in controlling non-residential contributions to their system is an outgrowth of the requirements of Public Law 92-500 and the subsequent receipt of an NPDES permit. The permit generally places limitations on the quality of discharge permissible by the POTW. As a result, it is important that interferences that might decrease the treatment plant's operating efficiency, or pollutants that might pass through a system be avoided. In addition, the permit may require that an enforceable ordinance be enacted. Municipalities are encouraged by the EPA to adopt local ordinances to control pollutants which might upset the POTW, decrease treatment efficiency, or cause a violation of the effluent limitations in the NPDES permit. Consequently, an effective program is essential not only to control pollutants entering the treatment plant which in turn affect its effluent, but also to develop and enforce an appropriate ordinance for the control of industrial pollutants.

Beyond fulfilling the specific requirements of the NPDES permit, a properly administered industrial pollutant control program also serves several other essential functions. Depending on the degree to which the POTW is cognizant of non-residential contributions to its system, the control program can serve as a basis for obtaining data on industrial contributors and in turn identify potential problem areas. The program should offer an ordered mechanism through which information can be transfered on the degree of compliance with ordinance requirements and Federal regulations. Above all, the control program provides the mechanism and enforcement tools necessary to assure treatment continuity and the protection of public facilities.

Additionally, industrial pollutant control programs may be used to establish procedures for implementing surcharge or user charge policies. The EPA Construction Grant Regulations (40 CFR 35) require construction grant applicants for funds authorized under Title II of PL-92-500 to establish and maintain a proportionate system of user charges for operation and maintenance costs and industrial cost recovery for capital costs. These requirements can be most effectively implemented through an industrial pollutant control program.

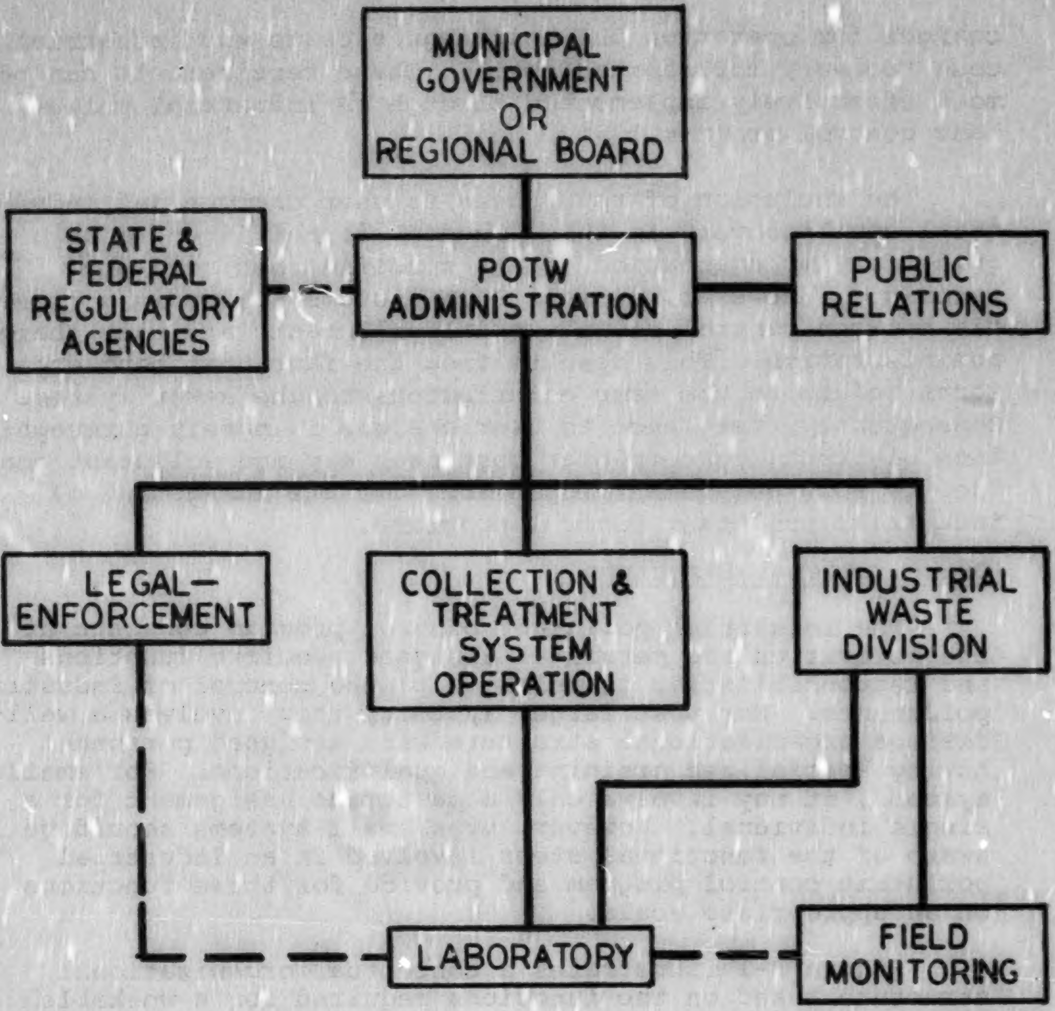
The inclusion of references to user charges and industrial cost recovery in this document is not intended as a guide for implementation of any specific cost recovery technique. However, in most POTW systems, there is a close tie between control of industrial pollutants and user charge administration. This results from the fact that both subjects relate to the same contributors to the sewer system. Consequently, reference to user charges is merely a recognition of mutual concern over cost recovery and pollutant control by POTW personnel responsible for the management of industrial pollutant control programs.

Organizational Structure

The industrial pollutant control program consists of the activities and personnel assigned specific functions and responsibilities in relation to the control of industrial pollutants. For most larger systems, this involves a well-defined organizational structure with assigned personnel having specialized training and qualifications. For smaller systems, it may involve only a part time assignment for a single individual. However, even small systems should be aware of the functional steps involved in an industrial pollutant control program and provide for these functions on an appropriate scale.

Figure B-1 illustrates a conceptual organizational structure based on the functions required for a workable control program. The manner in which these elements are organized can vary greatly depending on the local situation. The essential aspect is the need for an efficient information transfer mechanism. The typical organization shown outlines the interrelationship of the essential elements of a program.

Generally, the larger the system,the more complex the organization. Individual responsibilities also become more clearly defined as the system increases in size. For very small systems, outside experts are frequently utilized to provide engineering, legal and laboratory expertise. In order to supply the most meaningful guidance, the organization necessary for an effective industrial pollutant control program is specifically discussed in the following paragraphs in terms of small, medium and large systems.

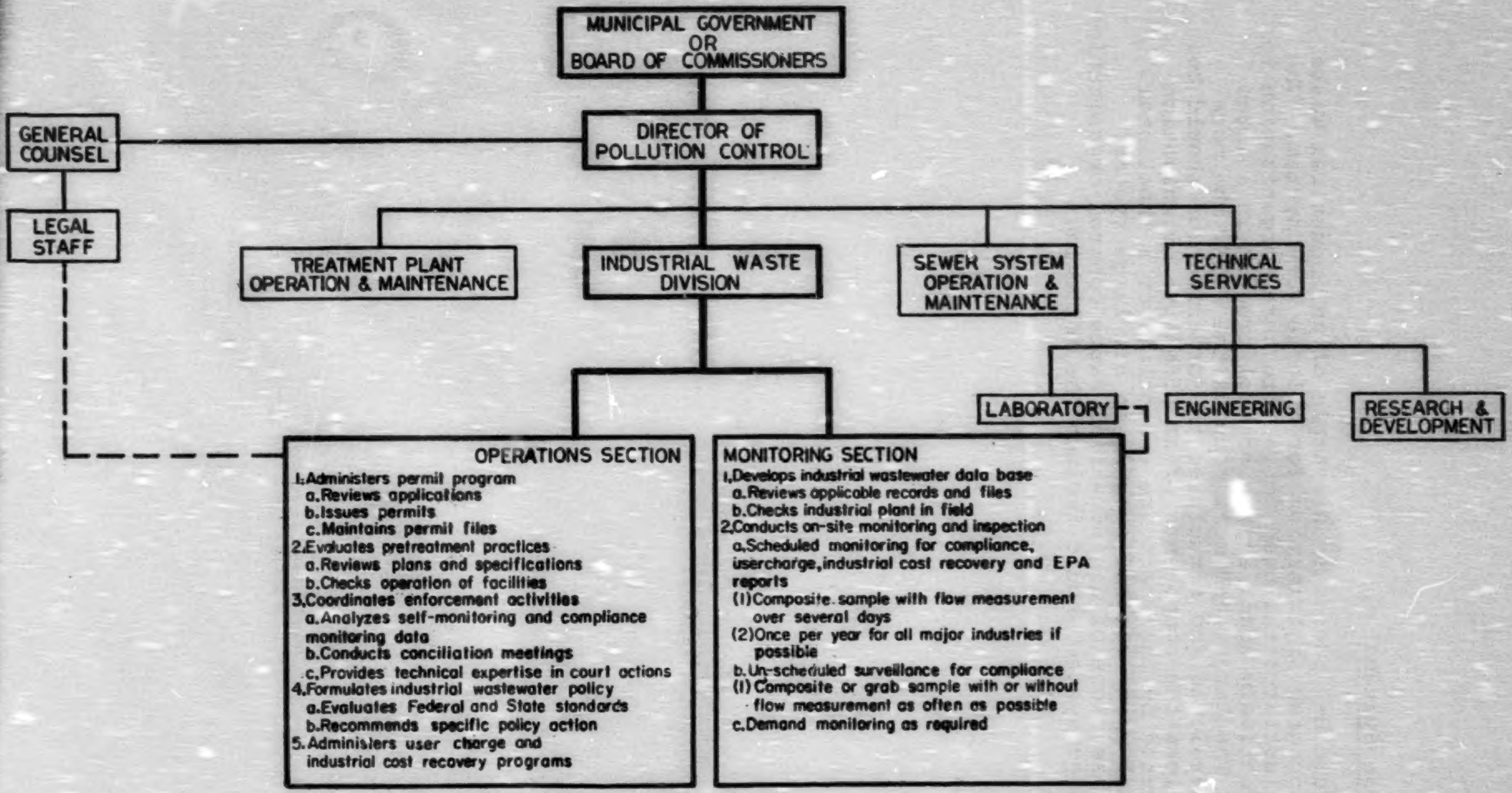

MUNICIPAL GOVERNMENT OR REGIONAL BOARD
STATE & FEDERAL REGULATORY AGENCIES
POTW ADMINISTRATION
PUBLIC RELATIONS
LEGAL— ENFORCEMENT
COLLECTION & TREATMENT SYSTEM OPERATION
INDUSTRIAL WASTE DIVISION
LABORATORY
FIELD MONITORING

CONCEPTUAL ORGANIZATION OF AN INDUSTRIAL WASTEWATER CONTROL PROGRAM

FIGURE B-1

Large Systems

Figure B-2 presents an example of an industrial waste control program organization for a large POTW system. The chart illustrates the need for a structured organization to most effectively administer a control program in a large system. The larger and more complex the POTW, the more highly developed and structured the organization should be. Nevertheless the components of an effective organization demonstrated by the chart are essential for a functional industrial waste control program in any large system. Specific sections of an industrial waste control organization for a large system should include the following:


MUNICIPAL GOVERNMENT OR BOARD OF COMMISSIONERS
DIRECTOR OF POLLUTION CONTROL
GENERAL COUNSEL
LEGAL STAFF
TREATMENT PLANT OPERATION & MAINTENANCE
INDUSTRIAL WASTE DIVISION
SEWER SYSTEM OPERATION & MAINTENANCE
TECHNICAL SERVICES
LABORATORY
ENGINEERING
RESEARCH & DEVELOPMENT

OPERATIONS SECTION

1. Administers permit program
   a. Reviews applications
   b. Issues permits
   c. Maintains permit files
2. Evaluates pretreatment practices
   a. Reviews plans and specifications
   b. Checks operation of facilities
3. Coordinates enforcement activities
   a. Analyzes self-monitoring and compliance monitoring data
   b. Conducts conciliation meetings
   c. Provides technical expertise in court actions
4. Formulates industrial wastewater policy
   a. Evaluates Federal and State standards
   b. Recommends specific policy action
5. Administers user charge and industrial cost recovery programs

MONITORING SECTION

1. Develops industrial wastewater data base
   a. Reviews applicable records and files
   b. Checks industrial plant in field
2. Conducts on-site monitoring and inspection
   a. Scheduled monitoring for compliance, usercharge, industrial cost recovery and EPA reports
      (1) Composite sample with flow measurement over several days
      (2) Once per year for all major industries if possible
   b. Un-scheduled surveillance for compliance
      (1) Composite or grab sample with or without flow measurement as often as possible
   c. Demand monitoring as required

TYPICAL ORGANIZATION OF A LARGE SYSTEM

FIGURE B-2

Administrative

Administrative responsibility for the program should rest with a single person who has intimate knowledge of all aspects of pollution control and wastewater treatment within the jurisdictional boundaries. In municipal systems, usually the Director of Public Works or Superintendent of Sanitation would be the appropriate individual. In regional authorities, there is most often a Board of Commissioners which has overall responsibility for the entire POTW system. Commissioners are generally appointed by appropriate governmental officials such as the governor of the state, and frequently act only in an overall policy and management capacity. In this sense, such boards can be considered as analogous to the mayor and council in a municipality. Day-to-day operations are usually administered by an Executive Director, General Manager, Chief Engineer or Superintendent who can be compared for these purposes to the Commissioner of Public Works in municipal operations.

Decisions pertinent to pretreatment policy should be made by this individual drawing upon information supplied by key subordinates. These subordinates should include personnel such as the Chief Industrial Waste Engineer, Chief Plant Operator, Chief Chemist, and other specialists concerned with the control program, including field investigators, engineers and attorneys.

Specific functions of the administrative section should include (1) basic policy decisions (2) management of budgetary needs (3) personnel administration and (4) coordination with the public and appropriate municipal, State and Federal authorities.

Industrial Waste Division

The individuals comprising the industrial waste division represent the heart of any industrial waste control program. Generally the division is comprised of engineers that conduct the program and secretarial personnel, field inspectors and laboratory technicians that provide the necessary support for effective operation. The engineering staff engaged in this activity should be the most knowledgeable group of individuals on all aspects of industrial wastewater within a given system. They should be thoroughly familiar with the operation and wastewater produced by industries in the system, pretreatment facilities utilized by the industries, applicable provisions of Federal and State standards and local ordinances and characteristics of the treatment processes utilized in the system. If a local permit program is employed, the industrial waste division would undoubtedly administer its operation. Generally this group will formulate industrial wastewater policy and recommend specific policies to the administrator for implementation. The industrial waste division would also generally coordinate enforcement activities and provide necessary technical expertise to the legal staff in court actions.

Staff levels vary considerably depending upon size, fiscal resources, organizational structure, number and type of industries present and the specific NPDES permit requirements of the system. The largest POTW systems in the country have as many as 50 to 80 individuals reporting to the Chief Industrial Waste Engineer. Smaller cities and regional authorities obviously require smaller staffs, with the level generally varying from approximately 1/2 to 2 individuals per 10 MGD, depending upon the factors indicated above.

Field Monitoring

The organization should include a group of inspectors whose only responsibility is the monitoring of non-residential contributors. These field investigations should include initial plant surveys, data acquisition at the plant site, and all follow-up monitoring and inspection activities. Monitoring and the general conduct of field investigations is an important subject which is covered in detail in Section D of these guidelines.

The field monitoring section should have total responsibility for surveillance of non-residential sources. Specific functions to be carried out by field inspectors include: (1) sampling and flow measurement at wastewater sources, (2) inspection of plant and pretreatment operations at the time of sampling, (3) maintenance of specialized field equipment, and (4) performance of specialized monitoring activities in connection with locating the source of problems within the system, enforcement activities, etc. The Metropolitan Sanitary District of Greater Chicago provides uniforms and badges for its inspectors to formalize their status in the community. This can be helpful in gaining quick access to industrial facilities when necessary. In any event, all field inspectors should be provided with proper credentials which should be carried for identification at all times.

Laboratory

An industrial pollutant control program will generally require some expansion of the typical laboratory required for control of biological treatment processes. As a result, additional personnel may be necessary to carry out analyses in conjunction with a monitoring program. Frequently, these technicians are incorporated into the existing laboratory organization, so that coordination with the industrial waste division is essential. Some POTW's are structured so that laboratory personnel engaged in industrial wastewater analysis report directly to the Chief Industrial Waste Engineer. Such an arrangement may be preferable for improved communications and delineation of responsibility.

Where this function is part of the overall laboratory responsibility, then data must be reported to the industrial waste division so that pretreatment performance can be evaluated. If any ordinance violations are suscepted, then analytical data would also be passed on to the legal staff for evaluation and possible enforcement action. The specific functions of the laboratory in connection with industrial wastewaters include (1) analysis of field samples, (2) maintenance of laboratory equipment and (3) proper record keeping and reporting in support of industrial waste division activities.

Legal - Enforcement

One or more attorneys may be required to provide legal services with regard to enforcement of ordinance regulations. Attorneys may not have full time responsibility in connection with ordinance enforcement. Instead the legal staff may serve the dual function of supporting legal action against ordinance violators, and general legal support of other activities in the water pollution control area.

For enforcement activity, the legal group should receive information directly from the industrial waste division staff, as well as from field monitoring and laboratory personnel. The special functions of enforcement include (1) assistance in evaluation of suspected ordinance violations, (2) notification of suspected violators, (3) participation in follow-up meetings with violators (4) preparation of briefs for litigation; and (5) court action.

Medium Size Systems

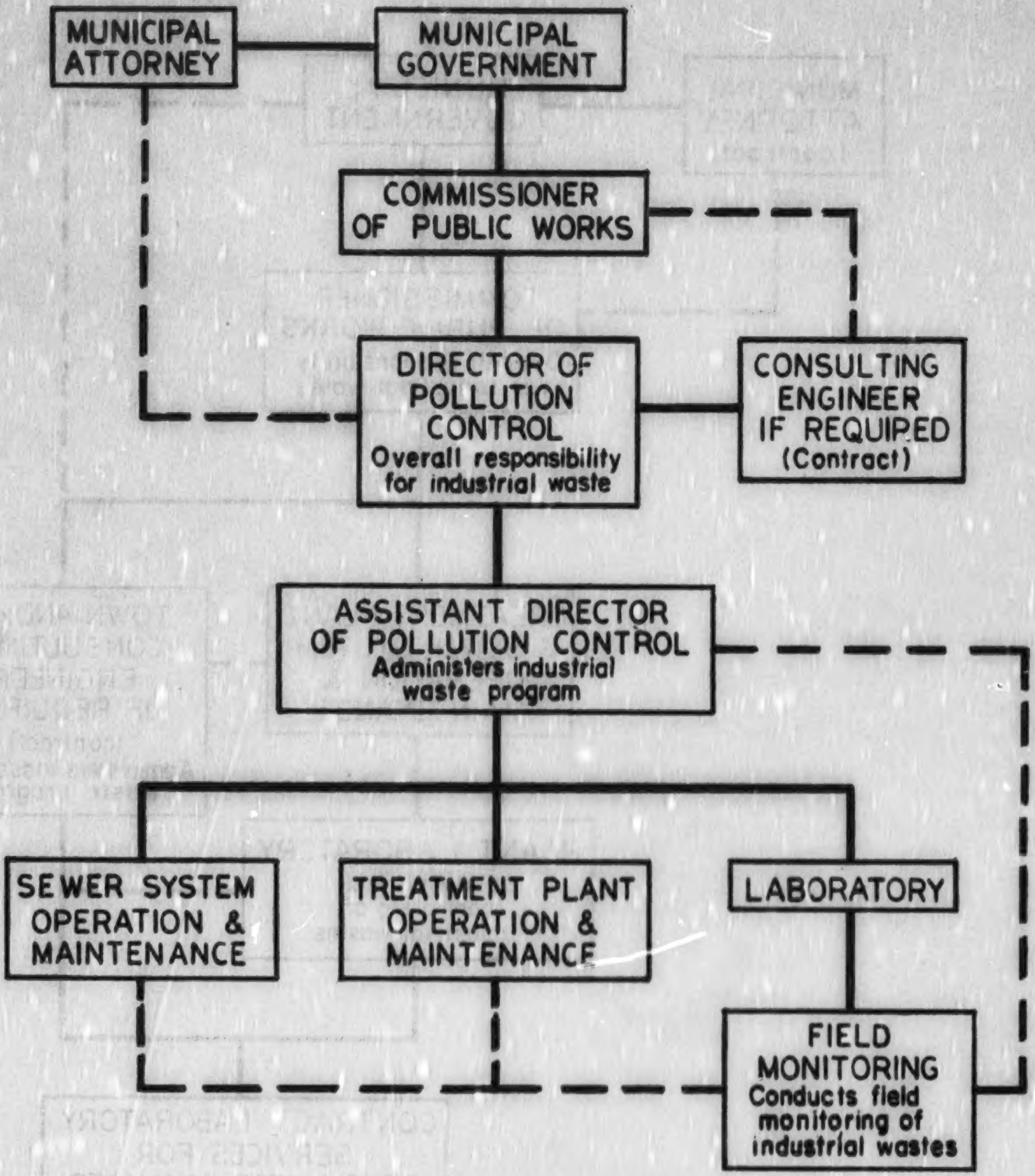
As the size of a POTW decreases, the operation of the industrial pollutant control program becomes less of a separate entity, and more entwined in the overall operation of the wastewater collection and treatment facility. Because of limited resources, administrative and laboratory personnel generally become responsible for both plant operations and control of pollutants contributed by non-residential sources. Figure B-3 provides a typical organization chart for a medium size POTW system.

Although fewer individuals are involved, the specific organizational elements of a control program must be maintained. The organization will not be as structured as in large systems, but the essential functions of industrial waste control must be performed in conjunction with other duties. Among these functions is the use of a field monitoring group to carry out plant inspections and effluent sampling. The field crew is essential for all of the specific monitoring requirements necessary to control industrial contributors to the system. Likewise, other specific functions of a control program would have to be maintained in a medium size system, such as ordinance enforcement, summary and analysis of industrial data and user charge administration. However, unlike the large system organization where individuals or groups of individuals have well defined task assignments, the control program for a medium size system will most likely contain individuals with multiple functions and responsibilities. Some medium size systems with many industrial contributors may find it necessary to have an industrial waste engineer or other individual specifically assigned to the control of discharges from these facilities.

Small Systems

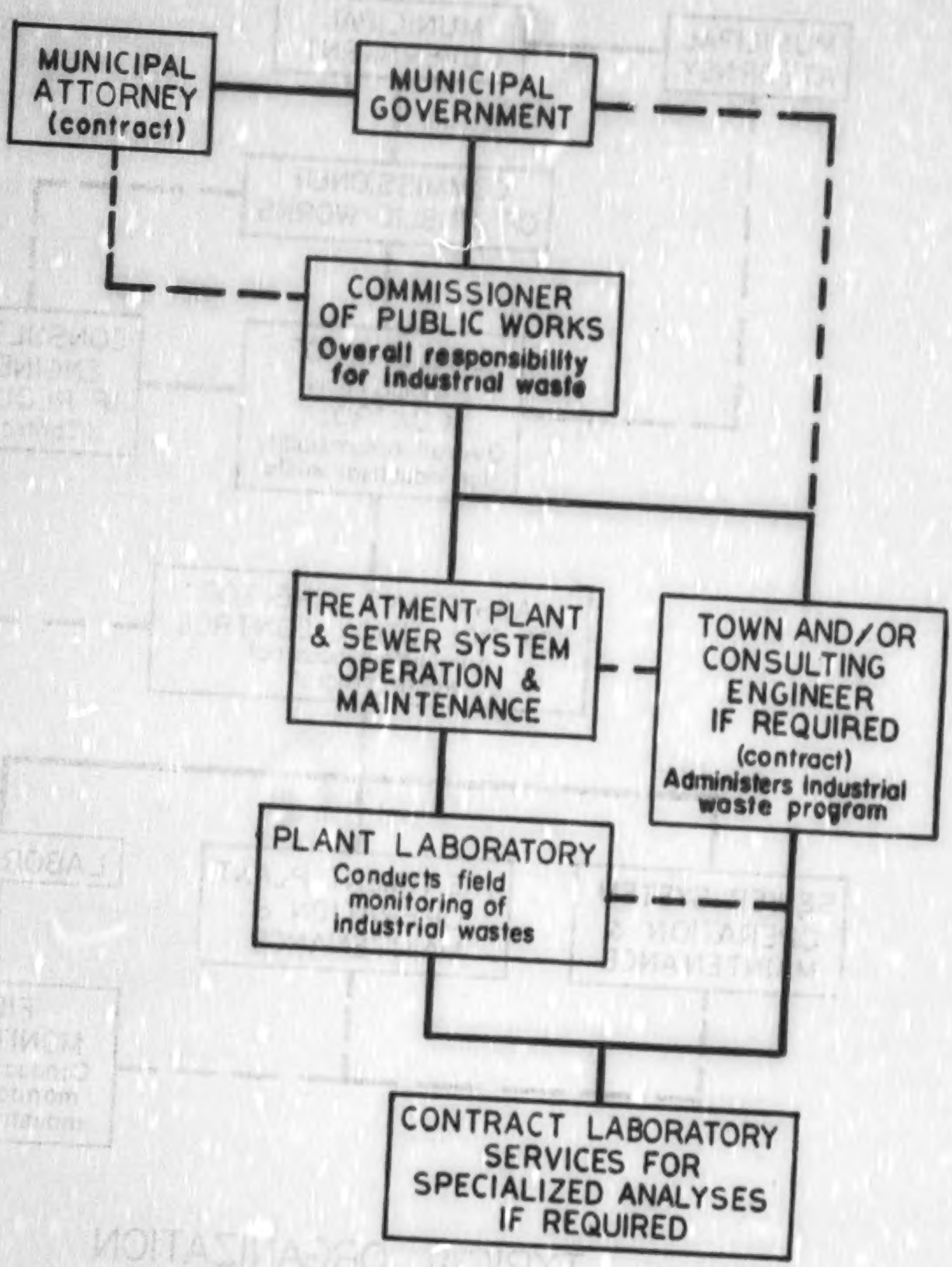
A large proportion of municipal POTW's that treat non-residential wastes fall into the small system category. In a small system, adequate resources would generally not be available to have any individual whose sole responsibility lies in the area of non-domestic pollutant control. Instead, all of the elements of an industrial pollutant control program that are delineated for large systems would have to be handled by personnel currently employed by the municipality. This is not unrealistic, since quite often a small system would be concerned with only a few, or even a single industrial contributor.

Figure B-4 illustrates an organizational arrangement for a typical small system. The structure shown is only one of several that could be effectively utilized in a small municipality. The variety encountered in the organization of small local governments suggests that a number of different


MUNICIPAL ATTORNEY
MUNICIPAL GOVERNMENT
COMMISSIONER OF PUBLIC WORKS
DIRECTOR OF POLLUTION CONTROL Overall responsibility for industrial waste
CONSULTING ENGINEER IF REQUIRED (Contract)
ASSISTANT DIRECTOR OF POLLUTION CONTROL Administers industrial waste program
SEWER SYSTEM OPERATION & MAINTENANCE
TREATMENT PLANT OPERATION & MAINTENANCE
LABORATORY
FIELD MONITORING Conducts field monitoring of industrial wastes

TYPICAL ORGANIZATION OF A MEDIUM SIZE SYSTEM

FIGURE B-3


MUNICIPAL ATTORNEY (contract)
MUNICIPAL GOVERNMENT
COMMISSIONER OF PUBLIC WORKS
Overall responsibility for industrial waste
TREATMENT PLANT & SEWER SYSTEM OPERATION & MAINTENANCE
TOWN AND/OR CONSULTING ENGINEER IF REQUIRED
(contract)
Administers industrial waste program
PLANT LABORATORY
Conducts field monitoring of industrial wastes
CONTRACT LABORATORY SERVICES FOR SPECIALIZED ANALYSES IF REQUIRED

TYPICAL ORGANIZATION OF A SMALL SYSTEM

FIGURE B-4

arrangements may be equally effective in the administration of an industrial pollutant control program. Nevertheless, in the small system case, generally one person has responsibility for monitoring and all specialized analysis is contracted to commercial laboratories. Similarly, the Director of Public Works would most likely have overall administrative responsibility in addition to performing the functions of the industrial waste engineer. A town engineer may be utilized for industrial waste control, reporting either to the Director of Public Works or directly to the governing body. The town engineer may be a full time employee if the needs of the system dictate, but he is most frequently a consulting engineer under a retainer type contract to the municipality. Specialized engineering requirements would usually be provided by either the town engineer or another consultant, with legal questions being handled by the municipal attorney. Since the NPDES permit program for POTW's, large or small, encourage implementation of Federal pretreatment standards, it is recommended that industrial pollutant control be implemented, even in the smallest of systems, where there are industrial users.

Financial Aspects

As might be expected, the cost of an industrial pollutant control program is a function of both the total system flow and of the proportion of the industrial wastewater contribution. A survey of municipal and regional sewerage systems with dry weather flows ranging from 15 to over 1,000 mgd was conducted. The survey showed that the annual direct cost of the industrial pollutant control program was generally in the order of $1,000 to $1,500 per million gallons per day of dry weather flow for systems having some significant portion of the total wastewater flow from industrial contributors. On this basis, the direct cost of a program covering industries for a system with an average flow of 50 mgd might be $50,000 to $75,000 per year (1975 dollars). Assuming an average salary level of $15,000 per year for personnel assigned to such a program, this system would support a staff of 3 to 5 persons.

Many systems have traditionally recovered the additional costs for treating and monitoring industrial wastewater through imposition of a user charge. These user charges have generally been related to the additional cost of treating for removal of suspended solids and BOD for industrial wastewaters that exceed domestic sewage in these components. In addition, PL 92-500 and the EPA construction grant regulations now require Federal construction grant recipients to establish and maintain a user charge program and a system of industrial cost recovery. The proportionate costs of an industrial pollutant control program such as outlined above, could be added to the user charge for the industrial contributors. In this way, the cost of the industrial pollutant control program would be distributed back to the contributor of the industrial wastewater being controlled. The cost of the control program could be recovered through a formula similar to the user charge formula where flow, loading, and a charge per connection or a charge per monitoring visit are used to determine an equitable cost distribution.

It should be noted that a well run, efficient industrial pollutant control program may be cost effective for both the POTW and the industrial contributors to the system. In some cases, the control program can pay for itself by means of increased user charge revenue derived from the identification and continued surveillance of industrial discharges to the POTW. Industries in the system may also benefit from the cost savings in economy of scale realized in cases where the municipality performs all of the monitoring functions. In such instances, lower costs should result from the use of a central laboratory and experienced monitoring field personnel, than the industry would incur in administering its own monitoring program. In particular, small industries with limited resources may prefer that the municipality perform this function.

Policy

Pretreatment

Most States or municipalities will require pretreatment in order to comply with the effluent limitations in the NPDES permit. Pollutants which would interfere with or pass through the POTW, resulting in a violation of any of these NPDES permit requirements, must be pretreated or rejected from the system. The following sections of the guidelines contain technical information to assist the State or municipality in determining specific pretreatment requirements. Pretreatment may be necessary for compatible or incompatible pollutants since both may be limited in the NPDES permit, and since either can cause plant upsets. Generally, however, where design capacity is available, except for shock loading provisions, pretreatment would not be required for compatible pollutants. Pretreatment is most commonly required for incompatible pollutants to prevent interference with treatment processes or pass through to receiving waters.

Federal pretreatment standards for fifteen categories of existing industrial sources have been promulgated (Appendix 1) but these standards, in effect, require no pretreatment as the wastewaters involved are generally susceptible to treatment in POTW facilities. However, this does not preclude local pretreatment requirements for compatible pollutants, if necessary. In particular, where design capacity is not available, pretreatment for compatible pollutants may be necessary to comply with NPDES permit effluent limitations. Pretreatment regulations for the remaining major existing industrial categories are still pending, with specific standards anticipated for most incompatible pollutants.

In addition to the regulatory aspects, pretreatment of incompatible wastes offers several operational advantages to POTW's. One significant advantage to the municipality is the specialized treatment that each wastewater contribution receives, and the fact that the potential for plant upset is greatly reduced by pretreatment. Local control can also serve as an insurance measure to protect against damage to the POTW from industrial wastes. Finally, the problem of incompatible pollutants contaminating the sludge from the POTW is reduced, as discussed in the following section on sludge disposal.

Joint Treatment

Joint treatment is a policy alternative that can be advantageous to both the POTW and the industry with regard to pollutants susceptible to treatment in POTW's. Generally, the treatment of industrial wastewaters in a POTW is incidental to its primary function of treating domestic sewage. Where the industrial contribution constitutes a significant portion of the total flow and substantially alters the concentration of pollutants normally contained in domestic sewage, the public agency may resort to the joint treatment approach. In this approach, the industry or industries contributing the pollutants is made a partner in the design and construction of the system, and the treatment works are designed to specifically remove the industrial pollutants. Both capital costs and operating costs are allocated to the industry and the public agency according to an agreement arrived at through negotiation, or as required by Federal regulations if construction grant funds are involved.

Joint treatment of industrial wastewaters with municipal domestic sewage offers these advantages:

- Savings in capital and operating expenses due to the economics of large-scale treatment facilities

- Increased flow over separate treatment which can result in reduced ratios of peak to average flows
- More efficient use of land resources, particularly in cases where available land for treatment facilities is scarce
- Improved operation (larger plants are potentially better operated than smaller plants)
- Increased number of treatment modules with resultant gains in reliability and flexibility
- More efficient disposal of sludges resulting from treatment of wastewaters containing pollutants susceptible to treatment in POTW's
- Utilization of the nutrients available in domestic wastes for biological treatment of industrial wastes which are nutrient deficient

Possible disadvantages of joint treatment are as follows:

- Where the pollutants are different from those usually treated in a POTW, design to treat the combined industrial-domestic waste stream for these pollutants may not be cost-effective (Reference F-25)
- Joint treatment by definition implies that the POTW was designed so as not to be interfered with by industrial wastes. However, where this requires design modifications ordinarily not required for domestic wastes, joint treatment may not be cost effective
- If joint treatment results in sludge disposal or utilization problems it may not be acceptable
- Some costs for the construction of joint treatment works solely to treat industrial pollutants are not eligible for Federal construction grants

Sludge Disposal

The ultimate disposal of sludges produced by either pretreatment or joint treatment operations is an important factor to consider. The POTW must be aware of the effect of its policies on environmental problems that may result from sludge disposal.

Generally pretreatment facilities will remove incompatible pollutants that may eventually be deposited in the sludge produced by the operation of the publicly owned treatment works. This can be a meaningful advantage in terms of the environmental effects of the ultimate disposal of sludge from the POTW. Incompatible pollutants in sludges can cause problems in most disposal techniques utilized, including incineration, landfills, ocean dumping and land spreading. Consequently, the removal of incompatible pollutants at their source by pretreatment is usually advantageous to the POTW in terms of its sludge disposal.

Nevertheless, incompatible pollutants removed by pretreatment also require an ultimate disposition, although the impact on the POTW may have been eliminated. In some cases the sludge produced by pretreatment operations may be pure enough to warrant by-product recovery or recycle. When this is not economically or technically feasible, disposal of sludge is necessary. Although the sludges produced by industrial pretreatment may not technically be under municipal regulatory control, the impact on other environmental areas should be noted. A possible approach to this problem would be an effort by the municipality to coordinate off-site disposal with appropriate regulatory agencies. If on-site disposal is utilized by the industry, attempts should be made to evaluate proposed disposal schemes to prevent future air and water pollution problems.

Summary

The treatment policy instituted by a POTW, whether pretreatment or joint treatment, should be determined on the basis of the conditions within the system. One of the most important factors to consider is the potential effect of the chosen course of action. The POTW must be aware of its policy's effect on critical environmental problems such as sludge disposal. As a result, the treatment policy should be instituted on the basis of a broad overview of all aspects and consequences of action taken.

Public Relations

It must be recognized that some industries using a public sewerage system will be reluctant to provide the necessary pretreatment facilities, particularly if they have been using the public system for some time and the effects of their contribution are not apparent. One way in which some public agencies have been able to enlist the support of their contributing industries is through the formation of an informal coordinating committee, which would consist of representatives of the affected industries and the public agency. This committee would explore all aspects of the Federal regulation, including pretreatment requirements and the NPDES permit for the POTW, and develop programs which would meet the requirement of the regulatory agencies. Such committees would be purely advisory and would not have any legal status, but could serve as a forum for the exchange of ideas.

SECTION C

LEGAL ASPECTS OF A CONTROL PROGRAM

Introduction

Legal Authority

Sewer Use Ordinances
  Historical Development
  Types of Ordinances

Recommended Ordinance for Industrial Use of Publicly Owned Sewerage Facilities
  Introductory Sections
  Regulatory Sections
    Excessive Discharge Rate
    Establishing Limitations for Pollutant Parameters
  Other Regulatory Sections
  Optional and Procedural Clauses

Recommended Ordinance

SECTION C
LEGAL ASPECTS OF A CONTROL PROGRAM

Introduction

The legal considerations inherent in the development and administration of an industrial pollutant control program are perhaps the most significant factor in the establishment of a viable program. The legal aspects are particularly important in instituting a control program in terms of providing the legal authority over industrial discharges to the sewerage system. In many cases, legal authority may be complicated by the structure of a sewer district or regional sewer authority. Many districts and regional authorities act essentially as wholesalers serving a number of political subdivisions, and do not have any direct contact with industries in the system. However, where the service area coincides with political boundaries, then legal authority can usually be established in a relatively simple manner, by the promulgation of an ordinance for the control of industrial use of publicly owned sewerage facilities.

The ordinance is the heart of any industrial pollutant control program, providing the essential mechanism for controlling the discharge from industries within the POTW system. Consequently, the ordinance must be carefully drawn to include all essential ingredients for the particular system. Once promulgated, the ordinance should be utilized for the control of all industrial wastewater discharges and the eventual enforcement of its terms against all violators. Therefore, the administration or enforcement of the ordinance is equally as important as its contents. Enforcement must be an integral part of any industrial pollutant control program. Consequently, legal assistance must be viewed as a continuing need which does not end once the ordinance is drawn and instituted. Proper enforcement requires teamwork between administrators, engineers, attorneys and field and laboratory personnel, with the legal role being the key to eventual resolution of problems through conciliation or court action.

Legal Authority

One of the most significant factors in the establishment of a viable industrial pollutant control program is the provision of adequate legal authority to develop, administer and enforce the program. Whatever agency is designated to operate the program must have sufficient power to enforce its rules and regulations on industrial users and to obtain the data necessary to monitor how its rules are being complied with.

If the service area of a public sewerage agency coincides with the boundaries of a political subdivision (city, county, etc.) the legal problems are usually relatively simple. However, if the sewerage agency serves more than one political jurisdiction, and particularly if it serves them essentially as a wholesaler, the problems can become more complicated. The solution depends to some extent on the legal structure of the sewerage agency. If it is only a voluntary association of independent municipalities, the agency will generally only have such authority as has been delegated to it by the compact creating the sewerage authority or district. If the sewerage agency has been established by a superior governmental jurisdiction, it then may be able to superimpose its authority on that of the local municipalities.

In any case, many existing regional sewerage authorities or districts are not able to legally interface with industries in the system because the industries discharge to municipal sewers which in turn connect to the regional agency. In such instances, the development and enforcement of ordinances controlling the discharge of industrial wastewaters is legally the responsibility of the individual municipalities in the system. They may look toward the regional agency for guidance in such matters, but nevertheless the municipalities in these cases would retain the legal authority to deal with industries in their systems in these situations.

With the advent of the NPDES permit program, it becomes increasingly important for the permittee to have the right to directly control the wastewaters from all contributors within the sewerage system. If an industrial discharger causes an upset in treatment plant operations and a resulting violation of the permit provisions, the POTW must have the right to directly and immediately control the industrial discharge. Regional agencies with the most effective industrial pollutant control programs at present have obtained the legal authority to control industries in their system directly. In some instances it was necessary to have the state legislature revise the compact or charter of the regional agency in order to obtain this authority. In other instances, renegotiation of the agreement between the regional agency and the municipalities in the service area might be the most direct method for obtaining legal authority. In particular, the 208 planning agency can provide assistance in obtaining legal authority. In any case, to comply with NPDES permit requirements, it is essential that the operating agency of the POTW obtain the power to deal directly with the industries contributing to its system in order to establish a viable industrial pollutant control program. POTW's faced with the problem of obtaining legal authority, should have their legal counsel examine all aspects of their charter or compact to determine the most direct method for acquiring such authority.

Sewer Use Ordinances

The following describes the content of sewer use ordinances, factors that control the content, the historical development of such ordinances, types of ordinances, and the application of sewer use ordinances to industrial users of publicly owned sewerage facilities.

Historical Development

The content of sewer use ordinances has evolved over the years roughly paralleling the increased sophistication in wastewater treatment facilities. Early ordinances were outgrowths of local plumbing and health codes, the contents of which were primarily devoted to standardization of materials used in the construction of sewers and connections thereto. Since sewage treatment was limited to settling of solid material, the content of ordinances at this stage focused on protection of sewers from clogging, corrosion and explosive hazards. Most ordinances are built around these basic provisions and have increased in scope as new needs have arisen.

With the advent of secondary treatment processes and the development of anaerobic digestion, closer control over certain dissolved organic and inorganic pollutants became necessary to prevent inhibitory effects in these units. In many instances, this type of control was provided by setting concentration limits for the acceptable discharge of critical pollutants.

The recent application of State and Federal water quality standards, which in many cases require the removal of even trace quantities of certain toxic pollutants, has caused many POTW's to establish direct control over significant industrial users. To gain information and control over these sources, many ordinances are now including permit provisions and self-monitoring provisions, or both.

Finally, as the costs of providing increased levels of treatment have risen, many POTW's have been forced to expand their revenue base. This has taken the form of a user charge provision for contributors whose wastes have greater strength than normal domestic sewage.

There is no single ordinance now in force that could be considered typical of all, or even most, ordinances currently being utilized. Effective control of sewer use has been obtained by both simple and complex ordinance structures.

Types of Ordinances

Two factors influence the size and content of a sewer use ordinance. The first of these is whether the ordinance is designed to be self-contained, or whether it simply states general provisions and relies on separately published rules and regulations for interpretation and implementation. The second factor is whether or not the ordinance incorporates a permit system for either industrial users or all users of the system. Obviously, an ordinance which is self-contained will be a longer document than one which is not. Permit systems, if used, will also add length. Generally, smaller communities with relatively few industries will use a self-contained ordinance and will not employ a permit system. Enforcement of the ordinance for the few industrial users in such cases can be achieved on the basis of personal contact between the pollution control officer and the industry plant manager. As the size of the POTW increases or, more importantly, as the number of industrial users increases, it becomes more difficult to provide flexibility for the numerous individual differences between users within the ordinance document itself. In these systems, a shorter document stating general provisions may be more effective. This type of ordinance is usually supplemented by a separate set of rules and regulations that explain the responsibilities of users with respect to the general provisions. The supplemental regulations may take the form of a permit system with or without industrial self-monitoring provisions. Permit and self-monitoring requirements are particularly useful for POTW's which are starting a comprehensive industrial discharge control program to meet NPDES requirements, and have to comply with a schedule for the development of information on industrial users. By using these provisions, the enforcement authority can expand the coverage of a smaller initial staff. In subsequent years, as both field and laboratory capability is increased, more direct methods of compliance monitoring can be used. In a fully developed industrial waste control program, compliance monitoring is usually the most effective tool for enforcement of the ordinance.

Regardless of the type of ordinance employed, its scope and complexity should be limited to the resources available to the enforcement authority. If enforcement of the ordinance relies heavily on a permit system and self-monitoring, then there should be an adequate office and field staff to issue and review permits and to check the periodic self-monitoring information. If enforcement is based on analysis of samples taken by the authority, then an adequate field and laboratory capability is necessary. In all cases, sufficient manpower should be available to follow up violations through the administrative procedures provided in the ordinance. Only by following up on each violation to gain compliance, will credibility for both the ordinance and the enforcement authority be established.

Recommended Ordinance for Industrial Use of Publicly Owned Sewerage Facilities

The recommended ordinance contained herein covers those portions of a complete sewer use ordinance which relate only to the industrial use of sewer systems. Excluded from the recommended ordinance are those parts of a typical ordinance which relate to standards for construction of sewers and appurtenances, provisions relating to the control of infiltration and inflow, user charges and other miscellaneous provisions. These portions of a typical sewer use ordinance are adequately covered in other reference sources.

The recommended ordinance is designed to be self-contained, and in its full form could be used independently as a separate document to control the industrial use of sewerage facilities. In addition, individual sections of the recommended ordinance may be used separately as an addendum or a major revision to an existing ordinance. Finally, individual clauses contained in the recommended ordinance may be used to supplement an otherwise complete document.

The recommended ordinance contains ten sections which can be grouped into four basic parts as follows:

A. Introductory sections consisting of the introduction, purpose, legislative background and definitions.

B. The body of the regulation consisting of prohibitions and limitations on discharges, control of prohibited wastes, sampling and analysis of wastes and enforcement procedures.

C. Optional add-on sections for a local permit program if desired.

D. Procedural clauses.

Introductory Section

The introductory section is simply a short statement of the content of the ordinance. It usually includes the precise location (city, county, State) of the area under jurisdiction of the ordinance. This is left blank in the recommended ordinance and, as well as all other blank spaces in the ordinance, must be completed to suit the enforcement agency responsible for implementation.

All ordinances contain a section on definition of terms used in the body of the ordinance. As few as 10, and as many as 50 definitions have been used depending on the sophistication of the ordinance. The recommended document contains an average length definition section. If a POTW has other sewer ordinances, then the definitions should be changed to be compatible with existing terminology. Many ordinances also have an entry for "other terms" which refers to the "Glossary-Water and Sewage Control Engineering" published by the Water Pollution Control Federation.

Regulatory Sections

This portion of the ordinance contains the essential regulations controlling discharges to sewerage systems, provisions for sampling and analysis, and procedures for enforcement of the ordinance.

Most ordinances cover prohibitions and limitations of wastewater discharges in two parts; general prohibitions on materials which have proven to be hazardous, or interfere with both collection and treatment systems, and limitations on certain critical pollutants which either interfere with or pass through the treatment facilities. The general prohibitions should delineate all objectionable materials as specifically as possible, and also should provide legal coverage for unanticipated problems. In this context, it should provide the POTW with the flexibility to effectively act against violators discharging materials not specifically named in the ordinance.

Excessive Discharge Rate

One instance in which flexibility is essential is in regard to excessive discharge rate. The recommended ordinance includes, in Section 2, Paragraph (a) (7) a general prohibition of wastes containing high concentrations of suspended solids, BOD or COD, or unusually high flows which would cause a treatment process upset and subsequent loss of treatment efficiency. This clause is of particular importance to many POTW systems. In a number of instances, industrial dischargers constitute a large percentage of the flow to a POTW. Excessive discharge can be extremely damaging in such cases. In addition, frequently industries with wide seasonal variations in their wastewater characteristics discharge to POTW's. Excessive discharge can also be a significant problem with industries having such seasonal variations in their plant effluent. In any case, it may be possible for a POTW to define excessive discharge more specifically for the system in question. This may be done in terms of design capacity, NPDES permit conditions, or by taking into account the most cost effective means of dealing with excessive discharge. If it is possible to delineate specific limits for excessive discharge incorporating local conditions, that is generally more desirable than the general clause contained in the recommended ordinance.

Establishing Limitations for Pollutant Parameters

The provisions for limitations on wastewater discharges have been shown in both general and specific terms in the recommended ordinance. Whichever option is utilized, the NPDES permit conditions and Federal pretreatment standards should be either referenced directly or used in the development of specific numerical limitations for applicable pollutant parameters. The general limitations provide flexibility for systems which are unable to determine what specific limitations to establish.

If sufficient information is available to select pollutant parameters and set specific numerical limitations, that option is usually preferable. However, it requires thorough knowledge of the sewerage system, data on industrial contributors, and familiarity with applicable water quality standards, Federal pretreatment standards and the provisions of the NPDES permit for the POTW. In establishing specific limits, there are three major factors to consider; (1) Federal pretreatment standards, (2) pass through of pollutants which would affect the POTW's NPDES permit or water quality standards and (3) inhibition of treatment processes or interference with sludge handling or disposal operations. The following paragraphs detail methods of determining concentration based pretreatment requirements. It should be noted, however, that the utilization of concentration pretreatment requirements in these guidelines is strictly an example. Pretreatment standards expressed as mass or concentration are being evaluated by EPA. Federal pretreatment standards may ultimately be based on one or both.

Federal Pretreatment Requirements

Federal pretreatment standards for new and existing sources within major industrial categories are in various states of development as described in other sections of these guidelines. When finalized, the limitations prescribed therein should be incorporated into the ordinance for all affected industries. As a result, specific numerical limitations for various incompatible pollutant parameters will be established for a number of major industries. Standards applicable to industries within a given system should be incorporated directly into this section of the ordinance. An efficient way in which this may be accomplished is by use of the Standard Industrial Category (SIC) code for each industry established by the Office of Management and Budget. The SIC numbers are utilized by the EPA in pretreatment rules and regulations, and thus provide a convenient method of cross-referencing for a given industrial category.

Pollutant Pass-Through

The second major consideration in setting specific limitations is the pass through of pollutants which would cause the POTW to violate its permit conditions or water quality standards. The method required to establish limits for industrial contributors based on permit or water quality provisions is "back-calculating," using the allowable discharge level in the standard as a starting point. This procedure requires knowledge of the removal capability of the treatment plant for the pollutant parameters of interest, in addition to information on dilution and background levels in the system. Frequently it is necessary to sample the influent and effluent of the treatment plant to establish its removal capability for a specific pollutant. If data for the system in question is not available, the removal information contained in Section F and Appendix 6 may be utilized to obtain average values for use in calculating specific pollutant limitations. Those portions of the document present the results of a survey of 269 treatment plants to determine the removal capability of treatment processes in regard to various pollutant parameters.

One major POTW system has developed a formula for use in establishing limits on its industrial contributors based on allowable pollutant concentrations in the treatment plant discharge set by the State.

There are at least two other approaches including economic equity between direct and indirect dischargers, and equity of pollutant loading to the stream. The following approach is exemplary only; no one approach is advocated by EPA. The formula in the exemplary approach is as follows:

$$L = PR \frac{Le}{1 - E} - La\,(1 - S)$$

where:

La = Average yearly influent concentration to the treatment plant (mg/l)

L = Maximum allowable concentration in an industrial wastewater discharge (mg/l).

Le = Allowable effluent concentration at the treatment plant (mg/l).

R = Dilution ratio = $\frac{Q^*}{Q}$

E = Treatment plant removal efficiency (%)

Q* = Total daily dry weather flow to the treatment plant (millions of gallons).

Q = Total daily industrial flow to which L applies (millions of gallons).

P = Assumed ratio of the maximum to average concentration for any wastewater component in an industrial wastewater discharge.

S = Assumed portion of total that can be controlled (%).

In this formula, L is determined for each pollutant parameter for which an Le has been established. The dilution ratio (R) is estimated by determining the total flow (Q) of all industries to be regulated for the pollutant in question, and dividing it into the total flow to the treatment plant (Q*). Values for E, the treatment plant removal efficiency for the pollutant parameter, should be based on operating experience of the specific treatment plant. If such information is unavailable, data for similar treatment facilities presented in Section F may be utilized. The peak to average ratio, P, is an estimate of the ratio of the maximum concentration of a constituent in an industrial effluent to the average concentration of the constituent for all industries included in Q. The more tightly a pollutant is controlled, the lower this ratio will be. The factor S is included to account for background levels in the system. If there is no background level for a particular pollutant, with industry providing the total concentration, then the value of S is 1.0. La is obtained from monitoring the pollutant parameters of interest in the treatment plant influent, and is included since the factor La (1-S) represents the background concentration of a specific pollutant which will not be controlled by the established limit.

The originators of the formula, the County Sanitation Districts of Los Angeles County, have utilized it to aid in determining allowable pollutant concentrations for industrial dischargers within the system. Table C-1 provides a numerical

TABLE C-1

CALCULATION OF MAXIMUM ALLOWABLE INDUSTRIAL DISCHARGE CONCENTRATIONS
COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY

CONSTITUENT	Le Ocean Plan Effluent Limit (mg/l)	E Removal Efficiency at plant w/Biolog. Secondary Treatment (%)	Lp Permissible Influent Limit to Plant $\frac{Le}{(1-E)}$ (mg/l)	La Average Treatment Plant Influent Concentration in 1974 (mg/l)	R Dilution Ratio $\frac{Q^*}{Q}$ (1)	P Assumed Ratio of Maximum to Average Concentration	S Assumed Fraction from Controllable Sources	L Calculated Maximum Concentration Allowable in Industrial Discharge L = PR (Lp-La (1-S))
Arsenic	0.01	48	0.02	0.025	35	10	0.47	2.4
Cadmium	0.02	73	0.09	0.032	35	10	0.86	29.4
Chromium	0.05	77	0.22	0.887	14	5	0.88	7.9
Copper	0.2	76	0.4(2)	0.635	23	5	0.76	28.5
Lead	0.05	80	0.25	0.370	19	10	0.75	29.9
Mercury	0.001	84	0.008	0.0012	350	15	0.60	39.5
Nickel	0.1	53	0.23	0.295	23	5	0.85	21.4
Silver	0.01	69	0.032	0.010	70	10	0.73	20.5
Zinc	0.3	77	1.50	1.99	18	5	0.84	113.5
Cyanide	0.1	55	0.24	0.430	18	10	0.93	37.8

Notes (1) Dilution ratios are based on the Industrial Waste Inventories of the Sanitation Districts. They are obtained by dividing 350 mgd by the total industrial wastewater flow of all industries identified in the inventory as significant contributors of the particular constituent.

(2) The limit of 0.4 mg/l copper is based upon the toxicity relationship of copper to biological wastewater treatment processes and is more restrictive than the influent limit required by the Ocean Plan effluent limit. The restrictive Lp value of 0.4 mg/l was used in lieu of La/(1-E) in the calculation of L.

Reference: C-47e, page 7 - 27

illustration of how the formula was applied to the ocean standards established by the State of California for arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, zinc, and cyanide. The table is included herein only as a guide for utilization of the formula, and not for the presentation of numerical information. It represents a revised version of the table in the reference indicated, to reflect an updating of the formula and the values of the individual factors based on subsequent data obtained by the County Sanitation Districts. POTW's applying the formula to their own situation must determine applicable values for all of the factors in the formula based on the characteristics of the individual system. In summary, the formula provides a systematic method for establishing specific numerical limitations for industrial pollutants based on the allowable concentration of each pollutant in the treatment plant effluent.

Inhibition or Interference

The third major consideration in setting numerical limitations is the inhibition of treatment processes or interference with sludge handling or disposal operation that may be caused by particular incompatible pollutants. In this connection, Section E and Appendix 5 of this document provide technical data on the inhibitory effects of both inorganic and organic constituents of industrial wastewaters. The data presented represents a summary of information available in the literature on this subject. It should be used as a guide in establishing a range of values for specific pollutants which may inhibit or upset treatment processes. Nevertheless, a number of factors within a given collection and treatment system will affect the acceptable level of a specific pollutant in a specific treatment plant. Of the many factors to be considered, the type of treatment process utilized is of prime importance. In addition to the inherent differences between unit processes such as activated sludge and trickling filtration, other treatment considerations such as chemical addition and wastewater flow pattern strongly affect inhibition characteristics. Consequently, information that may be available for a particular system should be utilized preferentially as compared to the data contained in these guidelines.

Additional factors to be considered in setting limits based on inhibition or interference are the natural dilution available from other contributors to the system, and background levels of the pollutant present in the collection system. Dilution is primarily a function of the size of the system, ranging from insignificant dilution in many small systems, to extremely high levels of dulution in very large systems. Several of the largest systems report that upset of treatment processes is extremely rare, regardless of the concentration of individual industrial contributions. The background level of a specific pollutant in a sewerage system should also be considered in setting numerical standards based on inhibition. Normally this is a difficult determination, but information from systems without industrial contributors may be helpful. Also, monitoring of all industrial dischargers and plant influent levels, with subsequent calculations will reveal background levels within the system.

In general, judgment is required in developing appropriate limitations based on inhibition of treatment processes, and all factors affecting the determination must be taken into account at the local level. A final consideration in establishing limitations based on inhibition, is the incorporation of an appropriate safety factor into the numerical limits for each pollutant. The inhibition data presented in these guidelines summarizes the results of studies reported in the literature indicating actual numerical values in which inhibition or process upset was observed for specific pollutants. Establishment of limitations based on this information requires the use of a suitable safety factor to ensure that adequate protection is provided for the treatment process.

In a fashion similar to that used in the preceding section for calculating the pass-through of incompatible pollutants, the maximum allowable concentration of inhibitory or interfering pollutants at the inlet to a POTW or a specific unit process can also be calculated.

Inhibition of Treatment Plant Operations

Calculation of pollutant levels at the influent to a treatment plant that will inhibit a unit process within the plant can be determined using the following equation:

$$L_p = \frac{L_i}{(1 - E_p)}$$

where:

L_p = Permissible influent limit to the treatment plant.

L_i = Maximum allowable concentration in the influent to the unit process that will not inhibit that unit process.

E_p = Removal efficiency of the unit processes upstream of the unit process of concern.

Once L_p has been determined using this formula, concentration limits at the point of industrial contribution can be ascertained by substituting L_p for L_e in the Los Angeles County formula and calculating L.

Both Li and Ep are unique for each treatment plant and should be determined in advance before attempting any calculations. For illustrative purposes, approximate values for Li and Ep can be obtained from Sections E and F of this document. In Section E, specific levels of incompatible pollutants which have been found to be deleterious to the efficient operation of biological treatment processes have been listed. The inhibitory levels given focus on the concentrations of particular dissolved chemical species in the influent to specific wastewater treatment unit processes. For example, in Table E-1 three ranges of copper concentrations experimentally found to be inhibitory to activated sludge, anaerobic digestion and nitrification processes are listed. From these ranges, values of 1, 5 and 0.1 mg/l have been used for Li in sample calculations for inhibition of activated sludge, anaerobic digestion and nitrification processes, respectively.

Similarly, Section F addresses the subject of removal and pass through of pollutants in POTW's. Table F-2 lists average removals for copper in primary and activated sludge plants as 26% and 57%, respectively. These numbers are used in the following sample calculations.

- Activated Sludge Processes

Using 1 mg/l for Li and 0.26 for Ep since some copper will be removed in primary treatment prior to the activated sludge process, the permissible copper concentration in the influent to the treatment plant is calculated as follows:

$$Lp = \frac{Li}{(1 - Ep)} = \frac{1}{(1 - .26)} = 1.35 \text{ mg/l}$$

- Nitrification Processes

Since a standard activated sludge plant will precede most nitrification processes, 0.57 is appropriate for Ep. Using 0.1 mg/l for Li, the permissible copper concentration to avoid inhibition of nitrification processes is calculated as follows:

$$Lp = \frac{Li}{1 - Ep} = \frac{0.1}{(1 - 0.57)} = 0.23 \text{ mg/l}$$

- Anaerobic Digestion

The type of calculation completed above cannot be directly applied to anaerobic digestion processes. In a digestor, inhibitory materials may be present as either aqueous species or as insoluble precipitates. High concentrations of potentially inhibitory materials, inorganics in particular, are frequently observed in digestor sludge with no apparent decrease in operating efficiency. This is explained by the fact that the high levels typically result from a concentration of insoluble inorganic materials, which do not impact on biological activity.

The major concern in anaerobic digestor operations is the concentration of inhibitory materials in the supernatant transferred with the sludge solids. Many of the concentrations of inhibitory materials cited in Section E for anaerobic sludge digestion refer to the concentration of pollutants in the supernatant entering the digestor with the raw sludge. The complicating factor in attempting to complete calculations such as those shown above is that the chemical environment in a digestor such as pH changes or the presence of sulfide, often causes the pollutant to precipitate before inhibiting the process. Therefore, calculations of limits based on inhibition of anaerobic digestion processes require a detailed evaluation of each individual plant's operations, and cannot be adequately illustrated in general terms.

It is important to observe that the inhibitory concentration observed for activated sludge processes may be higher than that for nitrification or anaerobic digestion processes. Since the activated sludge process utilizes many different bacteria, it can more readily withstand the effects of an inhibitory substance by adapting to the changing environment. On the other hand, nitrification and anaerobic digestion processes rely on the performance of a single strain of bacteria, thus making these processes less adaptable to the presence of inhibitory pollutants.

Interference with Sludge Handling or Disposal Operations

Essentially any inorganic material removed in a typical biological treatment process is contained in the sludge wasted from the system. Using the example of a 57% copper removal cited above for an activated sludge plant, it is possible to determine the level of copper expected in the raw sludge. Assuming 1.0 mg/l of copper is present in the influent to a 1 MGD plant, then the quantity of copper found in the sludge can be calculated as follows:

$$\text{Copper in Sludge} = \frac{1.0 \times 10^6\ (1.0)\ (.57)}{120,000} = 4.75 \text{ lb/day}$$

Since a typical activated sludge plant produces 20,000 gallons of sludge containing 1% solids, per million gallons daily, the concentration of copper in the waste sludge may be calculated as follows:

$$\text{Copper in Waste Sludge} = \frac{4.75\ (120,000)}{20,000} = 28.5 \text{ mg/l}$$

The dewatering of this sludge to a typical 20% concentration, prior to disposal, would increase the copper concentration to 570 mg/l. This calculation demonstrates that for a relatively small concentration of copper in the plant influent, the final concentration in the sludge is relatively high. As a result, it may be necessary to establish limits on the level of pollutants entering the plant, on the basis of the ultimate disposal of sludge. The example cited above shows that one of the most critical impacts of industrial contributions of incompatible pollutants may be interference with sludge disposal operations.

As with setting limits to avoid inhibition of anaerobic digestion processes, calculating limits to protect against interference with sludge handling and disposal methods is difficult. Factors such as digestor detention time, methods of decanting and mixing, and various other operational considerations may impact on the quality of dewatered sludge obtained. Consequently, factors of this type should be defined prior to attempting to calculate limits based on interference with sludge handling or disposal operations.

Summary

Responsible State or local regulating agencies should recognize that concentration based limitations have some inherent deficiencies, particularly where the ordinances' numerical limitations are intended to meet water quality requirements. Mainly, in cases where water and sewer costs are less than the cost of installing and operating pretreatment facilities, industrial dischargers may be tempted to use dilution to comply with the concentration limitations, resulting in the degradation of water quality. Dilution could result from the addition of city water, non-contact cooling water or relatively clean process water or storm water.

To detect diluters, the responsible authority should review industrial plans and specifications for pretreatment facilities, and use on-site inspection of pretreatment facilities and plant piping to determine that the appropriate pretreatment facilities have been installed, are being operated, and that there are no permanent connections for dilution water. Additionally, close surveillance of water meter readings and records can often pinpoint diluters. However, this is usually most effective when the concentration limitations first become effective and are first enforced. With these safeguards, concentration limitations will usually provide an effective and enforceable means of preventing interference with treatment processes or the pass through of pollutants which could cause the POTW to violate its permit conditions or water quality standards.

Other Regulatory Sections

Section 3 of the recommended ordinance establishes the authority and procedure for the control of prohibited wastes. It includes the necessary clauses relative to regulatory actions, submission of plans for pretreatment facilities, proper operation and maintenance of pretreatment facilities, admission of POTW personnel to industrial plants and reporting of accidental discharges. Section 4 of the ordinance is devoted to sampling and analysis of industrial wastewater. Several clauses are included with regard to monitoring and record keeping, encompassing the type and frequency of samples required. Section D of these guidelines includes a complete summary of monitoring information for the sampling and analysis of industrial wastewaters.

The sections of the recommended ordinance dealing with enforcement provides a structured approach for the handling of violations. The first step in the procedure is notification in writing of the violation, which would generally be followed by conference and conciliation. If these steps are unsuccessful in solving the problem, then more formal proceedings are instituted. The first is a show cause hearing, which provides the violator with an opportunity to show cause why an order should not be issued directing the discontinuance of the discharge. Show cause hearings are usually open to the public, and held before a hearing board composed of appropriate officials of the municipality, authority or district. Upon submission of all evidence, the hearing board has the option of issuing an order for the cessation of the discharge within a specified time period. If an order is issued, and not complied with, then court action is the next and final step in enforcement of the ordinance. This step-by-step approach to enforcement provides the maximum opportunity for the resolution of ordinance violations without resorting to court proceedings until absolutely necessary.

Optional and Procedural Clauses

An optional clause is included in the recommended ordinance pertaining to a permit program for industrial contributors to the system. Local permit programs are most applicable to large systems, and to date have been used successfully by several large regional agencies. Permit programs greatly increase the paper work associated with industrial pollutant control programs. Although the onus for filing permits is placed on the industries in the system, the POTW must nevertheless scrutinize the permits for completeness, truthfulness, accuracy, etc. The use of permits can be particularly advantageous in instituting a control program in a large system. At the outset, industries must provide all relevant information on their discharges, thus relieving the POTW staff from this initial data gathering task. Local permit programs offer an option which is systematic and thorough, but one which requires a well-trained capable staff to administer.

The procedural clauses included in the recommended ordinance serve several varying functions. The principal clause provides that the bulk of the ordinance remains in force if any section is declared invalid or unconstitutional. Only the affected section is no longer in force, thus "saving" the remainder of the ordinance. This section also references other related ordinances and reconciles differences that may exist between the various ordinances. Finally, the procedural clauses also set forth the date that the ordinance becomes effective.

Recommended Ordinance

The following pages contain the recommended industrial waste ordinance as outlined in the preceding paragraphs that may be utilized by a typical municipality, sewer district or authority. This ordinance is presented herein for reference purposes only, and it should be tailored to meet the needs of the specific governmental jurisdiction.

ORDINANCE NO. ______

AN ORDINANCE establishing rules and regulations for the discharge of wastewaters into the wastewater treatment system of the City of ________________.

WHEREAS, the Federal Water Pollution Control Act Amendments of 1972, P.L. 92-500 (hereinafter referred to as the "Act") have resulted in an unprecedented program of cleaning up our Nation's waters;

WHEREAS, this City has already made and will continue to make a substantial financial investment in its wastewater treatment system to achieve the goals of the Act; and,

WHEREAS, this City seeks to provide for the use of its wastewater treatment system by industries served by it without damage to the physical facilities, without impairment of their normal function of collecting, treating and discharging domestic wastewater, and without the discharge by this City's wastewater treatment system of pollutants which would violate the discharge allowed under its National Pollutant Discharge Elimination System (NPDES) permit and the applicable rules of all governmental authorities with jurisdiction over such discharges.

NOW, THEREFORE, BE IT ORDAINED AND ENACTED by the City Council of the City of ___________, County of ________________, State of__________, as follows:

SECTION 1: DEFINITIONS.

Unless the context specifically indicates otherwise, the following terms, as used in this Ordinance, shall have the meanings hereinafter designated:

(a) "Biochemical Oxygen Demand" (BOD) means the quantity of oxygen utilized in the biochemical oxidation of organic matter under standard laboratory procedure in five (5) days at 20°C, expressed in terms of weight and concentration (milligrams per liter).

(b) "Cooling Water" means the water discharged from any use such as air conditioning, cooling or refrigeration, during which the only pollutant added to the water is heat.

(c) "Compatible pollutant" means BOD, suspended solids, pH and fecal coliform bacteria, and such additional pollutants as are now or may be in the future specified and controlled in this City's NPDES permit for its wastewater treatment works where said works have been designed and used to reduce or remove such pollutants.

(d) "Director"/["Superintendent"] means the [director/superintendent of wastewater treatment system/of water pollution control/of public works] of this City or his duly appointed deputy, agent or representative.

(e) "Domestic wastes" means liquid wastes (i) from the non-commercial preparation, cooking and handling of food or (ii) containing human excrement and similar matter from the sanitary conveniences of dwellings, commercial buildings, industrial facilities, and institutions.

(f) "Garbage" means solid wastes from the domestic and commercial preparation, cooking and dispensing of food, and from the handling, storage and sale of food.

(g) "Incompatible pollutant" means any pollutant which is not a "compatible pollutant" as defined in this section.

(h) "Industrial wastewater" means the liquid wastes resulting from the processes employed in industrial, manufacturing, trade or business establishments, as distinct from domestic wastes.

(i) "National Pollutant Discharge Elimination System" (NPDES) means the program for issuing, conditioning and denying permits for the discharge of pollutants from point sources into the navigable waters, the contiguous zone and the oceans pursuant to section 402 of the Act.

(j) "Person" means any individual, firm, company, partnership, corporation, association, group or society, and includes the State of ____________, and agencies, districts, commissions and political subdivisions created by or pursuant to State law.

(k) "pH" means the logarithm of the reciprocal of the concentration of hydrogen ions in grams per liter of solution.

(l) "Pretreatment" means application of physical, chemical and biological processes to reduce the amount of pollutants in or alter the nature of the pollutant properties in a wastewater prior to discharging such wastewater into the publicly owned wastewater treatment system.

(m) "Pretreatment standards" means all applicable Federal rules and regulations implementing section 307 of the Act, as well as any nonconflicting State or local standards. In cases of conflicting standards or regulations, the more stringent thereof shall be applied.

(n) "Significant industrial user" means any industrial user of the City's wastewater treatment system whose flow exceeds (i) [50,000] gallons per day, or (ii) [five(5)] percent of the daily capacity of the treatment system.

(o) "Storm Water" means any flow occurring during or immediately following any form of natural precipitation and resulting therefrom.

(p) "Suspended solids" means the total suspended matter that floats on the surface of, or is suspended in, water, wastewater or other liquids, and which is removable by laboratory filtering.

(q) "Unpolluted Water" is water not containing any pollutants limited or prohibited by the effluent standards in effect, or water whose discharge will not cause any violation of receiving water quality standards.

(r) "User" means any person who discharges, causes or permits the discharge of wastewater into the City's wastewater treatment system.

(s) "User classification" means a classification of user based on the 1972 (or subsequent) edition of the Standard Industrial Classification (SIC) Manual prepared by the Office of Management and Budget.

(t) "Wastewater" means the liquid and water-carried industrial or domestic wastes from dwellings, commercial buildings, industrial facilities, and institutions, together with any groundwater, surface water, and storm water that may be present, whether treated or untreated, which is discharged into or permitted to enter the City's treatment works.

(u) "Wastewater treatment system" (system) means any devices, facilities, structures, equipment or works owned or used by the City for the purpose of the transmission, storage, treatment, recycling, and reclamation of industrial and domestic wastes, or necessary to recycle or reuse water at the most economical cost over the estimated life of the system, including intercepting sewers, outfall sewers, sewage collection systems, pumping, power, and other equipment, and their appurtenances; extensions, improvements, remodeling, additions, and alterations thereof; elements essential to provide a reliable recycled supply such as standby treatment units and clear well facilities; and any works, including site acquisition of the land that will be an integral part of the treatment process or is used for ultimate disposal of residues resulting from such treatment.

(v) Terms not otherwise defined herein shall be as adopted in the latest edition of Standard Methods for the Examination of Water & Wastewater, published by the American Public Health Association, the American Water Works Association and the Water Pollution Control Federation.

SECTION 2: PROHIBITIONS AND LIMITATIONS ON WASTEWATER DISCHARGES

(a) Prohibitions on Wastewater Discharges. No person shall discharge or deposit or cause or allow to be discharged or deposited into the wastewater treatment system any wastewater which contains the following:

(1) Oils and Grease. (A) Oil and grease concentrations or amounts from industrial facilities violating Federal pretreatment standards. (B) Wastewater from industrial facilities containing floatable fats, wax, grease or oils. [Optional: (C) Wax, grease or oil concentration of mineral origin of more than ( ) mg/l whether emulsified or not, or containing substances which may solidify

or become viscous at temperatures between 32° and 150°F (0° and 65°C) at the point of discharge into the system.] [Optional: (D) Total fat, wax, grease or oil concentration of more than ( )mg/l, whether emulsified or not, or containing substances which may solidify or become viscous at temperatures between 32° and 150°F (0° and 65°C) at the point of discharge into the system.]

(2) Explosive Mixtures. Liquids, solids or gases which by reason of their nature or quantity are, or may be, sufficient either alone or by interaction with other substances to cause fire or explosion or be injurious in any other way to the sewerage facilities or to the operation of the system. At no time shall two successive readings on an explosion hazard meter, at the point of discharge into the sewer system, be more than five percent (5%) nor any single reading over ten percent (10%) of the Lower Explosive Limit (L.E.L.) of the meter. Prohibited materials include, but are not limited to, gasoline, kerosene, naphtha, benzene, toluene, zylene, ethers, alcohols, ketones, aldehydes, peroxides, chlorates, perchalorates, bromates, carbides, hydrides and sulfides.

(3) Noxious Material. Noxious or malodorous solids, liquids or gases, which, either singly or by interaction with other wastes, are capable of creating a public nuisance or hazard to life, or are or may be sufficient to prevent entry into a sewer for its maintenance and repair.

(4) Improperly Shredded Garbage. Garbage that has not been ground or comminuted to such a degree that all particles will be carried freely in suspension under flow conditions normally prevailing in the public sewers, with no particle greater than one-half (1/2) inch in any dimension.

(5) Radioactive Wastes. Radioactive wastes or isotopes of such half-life or concentration that they do not comply with regulations or orders issued by the appropriate authority having control over their use and which will or may cause damage or hazards to the sewerage facilities or personnel operating the system.

(6) Solid or Viscous Wastes. Solid or viscous wastes which will or may cause obstruction to the flow in a sewer, or otherwise interfere with the proper operation of the wastewater treatment system. Prohibited materials include, but are not limited to, grease, uncomminuted garbage, animal guts or tissues, paunch manure, bones, hair, hides or fleshings, entrails, whole blood, feathers, ashes, cinders, sand, spent lime, stone or marble dust, metal, glass, straw, shavings, grass clippings, rags, spent grains, spent hops, waste paper, wood, plastic, tar, asphalt residues, residues from refining or processing of fuel or lubricating oil, and similar substances.

(7) Excessive Discharge Rate. Wastewaters at a flow rate or containing such concentrations or quantities of pollutants that exceeds for any time period longer than fifteen (15) minutes more than five (5) times the average twenty-four (24) hour concentration, quantities or flow during normal operation and that would cause a treatment process upset and subsequent loss of treatment efficiency.

(8) Toxic Substances. Any toxic substances in amounts exceeding standards promulgated by the Administrator of the United States Environmental Protection Agency pursuant to section 307(a) of the Act, and chemical elements or compounds, phenols or other taste- or odor-producing substances, or any other substances which are not susceptible to treatment or which may interfere with the biological processes or efficiency of the treatment system, or that will pass through the system.

(9) Unpolluted Waters. Any unpolluted water including, but not limited to, water from cooling systems or of stormwater origin, which will increase the hydraulic load on the treatment system.

(10) Discolored Material. Wastes with objectionable color not removable by the treatment process.

(11) Corrosive Wastes. Any waste which will cause corrosion or deterioration of the treatment system. All wastes discharged to the public sewer system must have a pH value in the range of [6] to [9] standard units. Prohibited materials, include, but are not limited to, acids, sulfides, concentrated chloride and fluoride compounds and substances which will react with water to form acidic products.

(b) Limitations on Wastewater Discharges. [use either Option A or Option B]

[Option A - General Limitations]

No person shall discharge or convey, or permit or allow to be discharged or conveyed, to a public sewer any wastewater containing pollutants of such character or quantity that will:

(1) Not be susceptible to treatment or interfere with the process or efficiency of the treatment system.

(2) Constitute a hazard to human or animal life, or to the stream or water course receiving the treatment plant effluent.

(3) Violate pretreatment standards.

(4) Cause the treatment plant to violate its NPDES permit or applicable receiving water standards.

[Option B - Specific Limitations]

The following are the maximum concentrations of pollutants allowable in wastewater discharges to the wastewater treatment system. Dilution of any wastewater discharge for the purpose of satisfying these requirements shall be considered a violation of this Ordinance.

Pollutant	Concentration (mg/l) or Mass Limitations (kg/kkg)
Arsenic	[Options: See, e.g. Federal Guidelines; State and Local Pretreatment Programs, Volume I, Section C]
Barium	
Boron	
Cadmium	
Chromium (total	
Chromium (Trivalent)	
Chromium (Hexavalent)	
Chlorinated Hydrocarbons	
Copper	
Cyanide	
Iron	
Lead	
Manganese	
Mercury	
Nickel	
Phenolic Compounds	
Phosphorus	
Selenium	
Silver	
Surfactants	
Zinc	
pH	
Temperature	Not over 150°F (except where higher temperatures are permitted by law)

(c) Special Agreements. Nothing in this section shall be construed as preventing any special agreement or arrangement between the City and any user of the wastewater treatment system whereby wastewater of unusual strength or character is accepted into the system and specially treated subject to any payments or user charges as may be applicable.

SECTION 3: CONTROL OF PROHIBITED WASTES

(a) Regulatory Actions. If wastewaters containing any substance described in Section 2 of this Ordinance are discharged or proposed to be discharged into the sewer system of the City or to any sewer system tributary thereto, the Director and [Corporation Counsel/City Attorney] may take any action necessary to:

(1) Prohibit the discharge of such wastewater.

(2) Require a discharger to demonstrate that in-plant modifications will reduce or eliminate the discharge of such substances in conformity with this Ordinance.

(3) Require pretreatment, including storage facilities, or flow equalization necessary to reduce or eliminate the objectionable characteristics or substances so that the discharge will not violate these rules and regulations.

(4) Require the person making, causing or allowing the discharge to pay any additional cost or expense incurred by the City for handling and treating excess loads imposed on the treatment system.

(5) Take such other remedial action as may be deemed to be desirable or necessary to achieve the purpose of this Ordinance.

(b) Submission of Plans. Where pretreatment or equalization of wastewater flows prior to discharge into any part of the wastewater treatment system is required, plans, specifications and other pertinent data or information relating to such pretreatment or flow-control facilities shall first be submitted to the Director for review and approval. Such approval shall not exempt the discharge or such facilities from compliance with any applicable code, ordinance, rule, regulation or order of any governmental authority. Any subsequent alterations or additions to such pretreatment or flow-control facilities shall not be made without due notice to and prior approval of the Director.

(c) Pretreatment Facilities Operations. If pretreatment or control of waste flows is required, such facilities shall be maintained in good working order and operated as efficiently as possible by the owner or operator at his own cost and expense, subject to the requirements of these rules and regulations and all other applicable codes, ordinances, and laws.

(d) Admission to Property. Whenever it shall be necessary for the purposes of these rules and regulations, the Director, upon the presentation of credentials, may enter upon any property or premises at reasonable times for the purpose of (1) copying any records required to be kept under the provisions of this Ordinance, (2) inspecting any monitoring equipment or method , and (3) sampling any discharge of wastewater to the treatment works. The Director may enter upon the property at any hour under emergency circumstances.

(e) Protection from Accidental Discharge. Each industrial user shall provide protection from accidental discharge of prohibited materials or other wastes regulated by this Ordinance. Facilities to prevent accidental discharge of prohibited materials shall be provided and maintained at the owner or operator's own cost and expense. Detailed plans showing facilities and operating procedures to provide this protection shall be submitted to the Director for review, and shall be approved by him before construction of the facility. Review and approval of such plans and operating procedures shall not relieve the industrial user from the responsibility to modify his facility as necessary to meet the requirements of this Ordinance.

(f) Reporting of Accidental Discharge. If, for any reason, a facility does not comply with or will be unable to comply with any prohibition or limitations in this Ordinance, the facility responsible for such discharge shall immediately notify the Director so that corrective action may be taken to protect the treatment system. In addition, a written report addressed to the Director detailing the date, time and cause of the accidental discharge, the quantity and characteristics of the discharge and corrective action taken to prevent future discharges, shall be filed by the responsible industrial facility within five (5) days of the occurrence of the noncomplying discharge.

SECTION 4: INDUSTRIAL WASTEWATER MONITORING AND REPORTING

(a) Discharge Reports.

(1) Every significant industrial user shall file a periodic Discharge Report at such intervals as are designated by the Director. The Director may require any other industrial users discharging or proposing to discharge into the treatment system to file such periodic reports.

(2) The discharge report shall include, but, in the discretion of the Director, shall not be limited to, nature of process, volume, rates of flow, mass emission rate, production quantities, hours of operation, concentrations of controlled pollutants or other information which relates to the generation of waste. Such reports may also include the chemical constituents and quantity of liquid materials stored on site even though they are not normally discharged. In addition to discharge reports, the Director may require information in the form of [Industrial Discharge Permit Applications and (optional)] self-monitoring reports.

(b) Records and Monitoring.

(1) All industrial users who discharge or propose to discharge wastewaters to the wastewater treatment system shall maintain such records of production and related factors, effluent flows, and pollutant amounts or concentrations as are necessary to demonstrate compliance with the requirements of this Ordinance and any applicable State or Federal pretreatment standards or requirements.

(2) Such records shall be made available upon request by the Director. All such records relating to compliance with pretreatment standards shall be made available to officials of the U. S. Environmental Protection Agency upon demand. A summary of such data indicating the industrial user's compliance with this Ordinance shall be prepared [quarterly] (optional) and submitted to the Director.

(3) The owner or operator of any premises or facility discharging industrial wastes into the system shall install at his own cost and expense suitable monitoring equipment to facilitate the accurate observation, sampling, and measurement of wastes. Such equipment shall be maintained in proper working order and kept safe and accessible at all times.

(4) The monitoring equipment shall be located and maintained on the industrial user's premises outside of the building. When such a location would be impractical or cause undue hardship on the user, the Director may allow such facility to be constructed in the public street or sidewalk area, with the approval of the public agency having jurisdiction over such street or sidewalk, and located so that it will not be obstructed by public utilities, landscaping or parked vehicles.

(5) When more than one user can discharge into a common sewer, the Director may require installation of separate monitoring

equipment for each user. When there is a significant difference in wastewater constituents and characteristics produced by different operations of a single user, the Director may require that separate monitoring facilities be installed for each separate discharge.

(6) Whether constructed on public or private property, the monitoring facilities shall be constructed in accordance with the Director's requirements and all applicable construction standards and specifications.

(c) Inspection, Sampling and Analysis.

(1) Compliance Determination. Compliance determinations with respect to Section 2 prohibitions and limitations may be made on the basis of either instantaneous grab samples or composite samples of wastewater. Composite samples may be taken over a 24 hour period, or over a longer or shorter time span, as determined necessary by the Director to meet the needs of specific circumstances.

(2) Analysis of Industrial Wastewaters. Laboratory analysis of industrial wastewater samples shall be performed in accordance with the current edition of "Standard Methods", "Methods for Chemical Analysis of Water and Waste" published by the U. S. Environmental Protection Agency or the "Annual Book of Standards, Part 23, Water, Atmospheric Analysis" published by the American Society for Testing and Materials. Analysis of those pollutants not covered by these publications shall be performed in accordance with procedures established by the [State Department of Environmental Health.]

(3) Sampling Frequency [Optional]. Sampling of industrial wastewater for the purpose of compliance determination with respect to Section 2 prohibitions and limitations will be done at such intervals as the Director

may designate. However, it is the intention of the Director to conduct compliance sampling or to cause such sampling to be conducted for all major contributing industries at least once in every (1 year) (optional) period.

SECTION 5: INDUSTRIAL DISCHARGE PERMIT SYSTEM [OPTIONAL]

(a) Wastewater Discharge Permits Required. All significant industrial users proposing to connect to or discharge into any part of the wastewater treatment system must first obtain a discharge permit therefor. All existing significant industrial users connected to or discharging to any part of the City system must obtain a wastewater discharge permit within ninety (90) (optional) days from and after the effective date of this Ordinance.

(b) Permit Application. Users seeking a wastewater discharge permit shall complete and file with the Director an application on the form prescribed by the Director, and accompanied by the applicable fee. In support of this application, the user shall submit the following information:

(1) Name, address, and SIC number of applicant.

(2) Volume of wastewater to be discharged.

(3) Wastewater constituents and characteristics including, but not limited to, those set forth in Section 2 of this Ordinance as determined by a reliable analytical laboratory.

(4) Time and duration of discharge.

(5) Average and [30] (optional) minute peak wastewater flow rates, including daily, monthly and seasonal variations, if any.

(6) Site plans, floor plans, mechanical and plumbing plans and details to show all sewers and appurtenances by size, location and elevation.

(7) Description of activities, facilities and plant processes on the premises including all materials and types of materials which are, or could be, discharged.

(8) Each product produced by type, amount, and rate of production.

(9) Number and type of employees, and hours of work.

(10) Any other information as may be deemed by the Director to be necessary to evaluate the permit application.

The Director will evaluate the data furnished by the user and may require additional information. After evaluation and acceptance of the data furnished, the Director may issue a wastewater discharge permit subject to terms and conditions provided herein.

(c) Permit Conditions. Wastewater discharge permits shall be expressly subject to all provisions of this Ordinance and all other regulations, user charges and fees established by the City. The conditions of wastewater discharge permits shall be uniformly enforced in accordance with this Ordinance, and applicable State and Federal regulations. Permit conditions will include the following:

(1) The unit charge or schedule of user charges and fees for the wastewater to be discharged to the system.

(2) The average and maximum wastewater constituents and characteristics.

(3) Limits on rate and time of discharge or requirements for flow regulations and equalization.

(4) Requirements for installation of inspection and sampling facilities, and specifications for monitoring programs.

(5) Requirements for maintaining and submitting technical reports and plant records relating to wastewater discharges.

(6) Daily average and daily maximum discharge rates, or other appropriate conditions when pollutants subject to limitations and prohibitions are proposed or present in the user's wastewater discharge.

(7) Compliance schedules.

(8) Other conditions to ensure compliance with this Ordinance.

(d) Duration of Permits. Permits shall be issued for a specified time period, not to exceed (five) (optional) years. A permit may be issued for a period of less than (one) (optional) year, or may be stated to expire on a specific date. If the user is not notified by the Director (30) (optional) days prior to the expiration of the permit, the permit shall automatically be extended for (x) months. The terms and conditions of the permit may be subject to modification and change by the (responsible official) during the life of the permit, as limitations or requirements as identified in Section 2 are modified and changed. The user shall be informed of any proposed changes in his permit at least (30) (optional) days prior to the effective date of change. Any changes or new conditions in the permit shall include a reasonable time schedule for compliance.

(e) Transfer of a Permit. Wastewater discharge permits are issued to a specific user for a specific operation. A wastewater discharge permit shall not be reassigned or transferred or sold to a new owner, new user, different premises, or a new or changed operation.

(f) Revocation of Permit. Any user who violates the following conditions of his permit or of this Ordinance, or of applicable State and Federal regulations, is subject to having his permit revoked. Violations subjecting a user to possible revocation of his permit include, but are not limited to, the following:

(1) Failure of a user to accurately report the wastewater constituents and characteristics of his discharge;

(2) Failure of the user to report significant changes in operations, or wastewater constituents and characteristics;

(3) Refusal of reasonable access to the user's premises for the purpose of inspection or monitoring; or,

(4) Violation of conditions of the permit.

SECTION 6: ENFORCEMENT PROCEDURES

(a) Notification of Violation. Whenever the Director finds that any person has violated or is violating his Ordinance, or any prohibition, limitation or requirement contained herein, he may serve upon such person a written notice stating the nature of the violation and providing a reasonable time, not to exceed thirty (30) days, for the satisfactory correction thereof.

(b) Show Cause Hearing.

(1) If the violation is not corrected by timely compliance, the Director may order any person who causes or allows an unauthorized discharge to show cause before the (hearing authority) why service should not be terminated. A notice shall be served on the offending party, specifying the time and place of a hearing to be held by the [hearing authority] regarding the violation, and directing the offending party to show cause before [said authority] why an order should not be made directing the termination of service. The notice of the hearing shall be served personally or by registered or certified mail (return receipt requested) at least [ten] days before the hearing. Service may be made on any agent or officer of a corporation.

(2) The [hearing authority] may itself conduct the hearing and take the evidence, or may designate any of its members or any officer or employee of the [assigned department] to:

(A) Issue in the name of the [hearing authority] notices of hearings requesting the attendance and testimony of witnesses and the production of evidence relevant to any matter involved in any such hearings.

(B) Take the evidence.

(C) Transmit a report of the evidence and hearing, including transcripts and other evidence, together with recommendations to the [hearing authority] for action thereon.

(3) At any public hearing, testimony taken before the hearing authority or any person designated by it, must be under oath and recorded stenographically. The transcript, so recorded, will be made available to any member of the public or any part to the hearing upon payment of the usual charges therefor.

(4) After the [hearing authority] has reviewed the evidence, it may issue an order to the party responsible for the discharge directing that, following a specified time period, the sewer service be discontinued unless adequate treatment facilities, devices or other related appurtenances shall have been installed or existing treatment facilities, devices or other related appurtenances are properly operated, and such further orders and directives as are necessary and appropriate.

(c) Legal Action. Any discharge in violation of the substantive provisions of this Ordinance or an Order of the [hearing authority] shall be considered a public nuisance. If any person discharges sewage, industrial wastes or other wastes into the City treatment system contrary to the substantive provisions of this Ordinance or any Order of the [hearing authority], the [Corporation Counsel/City Attorney] shall commence an action for appropriate legal and/or equitable relief in the [Circuit] Court of this County.

SECTION 7: PENALTY; COSTS

Any person who is found to have violated an Order of the [hearing authority] or who willfully or negligently failed to comply with any provision of this Ordinance, and the orders, rules and regulations issued hereunder, shall be fined not less than [One Hundred Dollars] (optional) nor more than [One Thousand Dollars] (optional) for each offense. Each day on which a violation shall occur or continue shall be deemed a separate and distinct offense. In addition to the penalties provided herein, the City may recover reasonable attorneys' fees, court costs, court reporters' fees and other expenses of litigation by appropriate suit at law against the person found to have violated this Ordinance or the orders, rules and regulations issued hereunder.

SECTION 8: SAVINGS CLAUSE

If any provision, paragraph, word, section or article of this Ordinance is invalidated by any court of competent jurisdiction, the remaining provisions, paragraphs, words, sections, and articles shall not be affected and shall continue in full force and effect.

SECTION 9: CONFLICT

All ordinances and parts of ordinances inconsistent or conflicting with any part of this Ordinance are hereby repealed to the extent of such inconsistency or conflict.

SECTION 10: EFFECTIVE DATE

This Ordinance shall be in full force and effect [Option A] from and after its passage, approval and publication, as provided by law. [Option B] on the _____ day of _____, 19__.

INTRODUCED the ___day of _____, 19__.

FIRST READING: ____________, 19__.
SECOND READING: ____________, 19__.

PASSED this ___ day of _______, 19__.

AYES:
NAYS:
ABSENT:
NOT VOTING:

APPROVED by me this ___day of ______, 19__.

____
MAYOR

ATTEST: _______________(Seal) City Clerk

Published the _____ day of ________, 19__.

SECTION D
MONITORING

- Functions of a Monitoring Program
  - Introduction
  - Development of a Data Base
  - Scheduled Monitoring
  - Unscheduled Surveillance
  - Demand Monitoring
  - Self-Monitoring
  - Enforcement

- Field Considerations in Monitoring
  - Background
  - Scheduled Monitoring
    - Scheduling
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  - Demand Monitoring

- Laboratory Considerations in Monitoring
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- Conducting an Industrial Waste and Pretreatment Survey

SECTION D
MONITORING

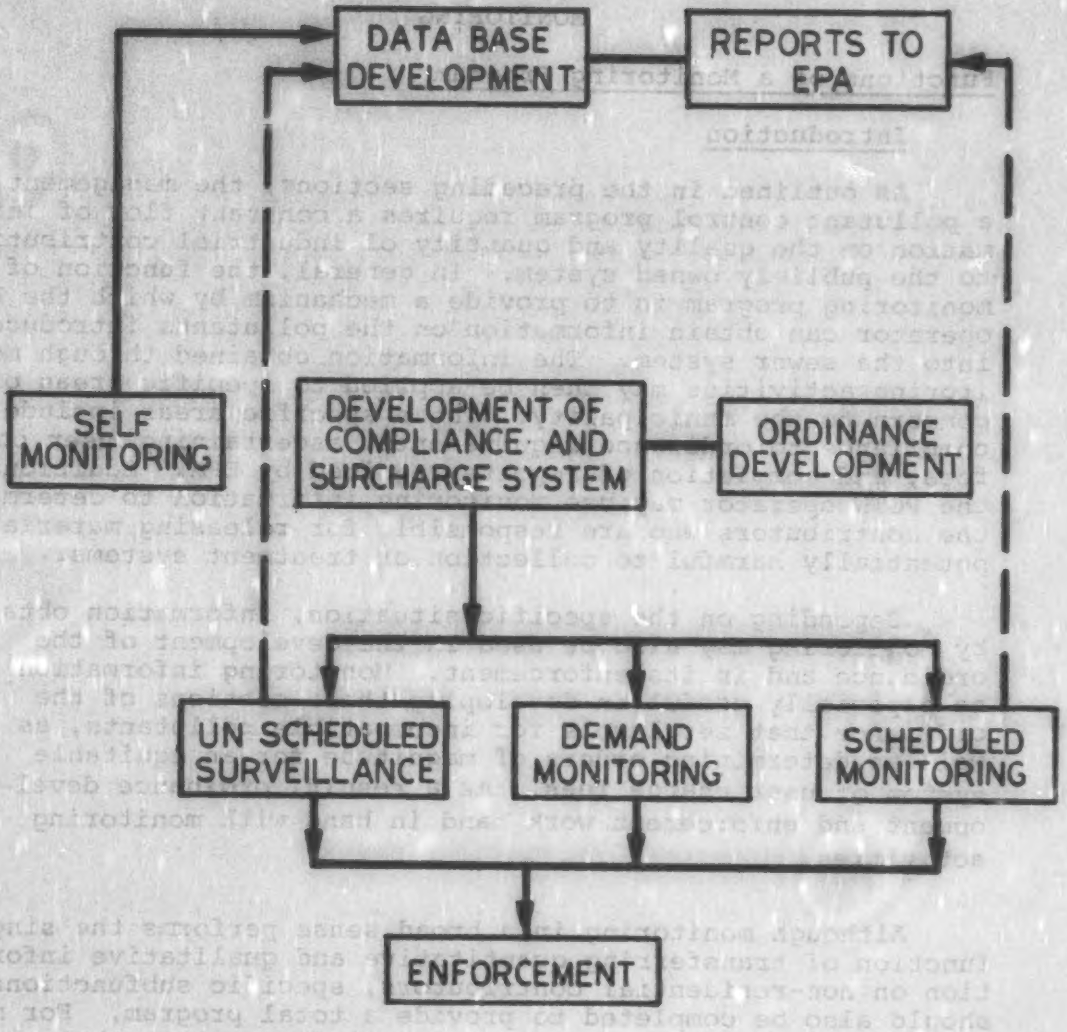
Functions of a Monitoring Program

Introduction

As outlined in the preceding sections, the management of a pollutant control program requires a constant flow of information on the quality and quantity of industrial contributions to the publicly owned system. In general, the function of a monitoring program is to provide a mechanism by which the POTW operator can obtain information on the pollutants introduced into the sewer system. The information obtained through monitoring activities may then be applied to specific areas of concern to the municipality. These specific areas include compliance to ordinance requirements, ascertaining user charge fees, and completion of reports required by EPA. Additionally, the POTW operator may use monitoring information to determine the contributors who are responsible for releasing materials potentially harmful to collection or treatment systems.

Depending on the specific situation, information obtained by monitoring may also be used in the development of the ordinance and in its enforcement. Monitoring information can be especially useful in developing those sections of the ordinance that set levels for incompatible pollutants, as well as determining orders of magnitude for an equitable system of user charge fees. As a result, ordinance development and enforcement work hand in hand with monitoring activities.

Although monitoring in a broad sense performs the single function of transferring quantitative and qualitative information on non-residential contributors, specific subfunctions should also be completed to provide a total program. For monitoring, there are well defined intermediate steps that should be accomplished during the course of the overall program. In a well managed system for industrial pollutant control, information should be transferred in a closed loop where monitoring, ordinance compliance, ordinance enforcement and user charge fees determination all input to one another. A typical monitoring feedback system is depicted in Figure D-1. Each of the monitoring functions shown are discussed in detail in the following paragraphs. The interrelation of each function is addressed with commentary included on the implementation of the specific monitoring activity.


DATA BASE DEVELOPMENT
REPORTS TO EPA
SELF MONITORING
DEVELOPMENT OF COMPLIANCE AND SURCHARGE SYSTEM
ORDINANCE DEVELOPMENT
UN SCHEDULED SURVEILLANCE
DEMAND MONITORING
SCHEDULED MONITORING
ENFORCEMENT

MONITORING FEEDBACK SYSTEM

FIGURE D-1

Development of a Data Base

NPDES permits issued to POTW's often stipulate that the permittee must promulgate an enforceable ordinance. In addition, the permittee is required to submit reports and forms to the EPA regional office concerning the characteristics of contributions from major contributing industries (MCI's) within their system. Once an ordinance is in effect, reports on the progress of the MCI's toward compliance are usually required. The ordinance cannot be completely developed unless the municipality or authority has acquired preliminary information on non-residential contributions in the system. The mechanism for obtaining this data base is provided by the requirement in the typical NPDES permit that the permittee must submit, for each MCI within its system, an EPA Standard Form A - Municipal; Section IV entitled "Industrial Waste Contribution to Municipal Systems." Completion of the Section IV form requires information on production, wastewater flow and wastewater concentration. This information can serve as an initial data base, from which the municipality or authority can plan or implement its industrial pollutant control program. The Section IV form is only required by EPA for MCI's. However, this form provides a convenient tool that could be utilized by municipalities to obtain data on all industrial establishments within their jurisdiction. Consequently, a systematic approach to obtaining Section IV information should be developed. An important preliminary step in this regard is the location, evaluation and classification of non-residential contributors. In order to develop the Section IV data base, two specific tasks must be completed; the identification of non-residential contributors, and differentiating between major and minor sources.

For the small municipality, identifying contributors within the wastewater collection system is usually an easy task. The plant operator, or the system's superintendent, is generally familiar with the area served, and the contributors within it. For larger systems, and those small systems where this familiarity does not exist, identifying industrial contributors can be more complex. The location of wastewater sources can be accomplished by using the various listings of commercial establishments that are available to the public. Such listings include:

--Labor Department Records
--Property Tax Records
--Chamber of Commerce Rosters
--Census Bureau Records
--Local Telephone Directory
--Water Consumption Records

These documents can provide a variety of information on industrial establishments, such as location, product line, production volume and water usage.

Combining the information that can be obtained from the individual listings can provide the municipality with an understanding of which contributors may be considered major or minor. Using the criteria for an MCI established by the EPA, a preliminary breakdown between major and minor contributors generally can be established on the basis of flow. In addition to the Federal definition of a major industry, the municipality must decide, on the basis of specific factors in the POTW system, which industrial facilities to consider significant contributors. The EPA definition of an MCI should be used as a first step in a major-minor delineation. However, other factors including water quality standards, and the POTW's sensitivity to a particular type of wastewater, must also be taken into account. Establishing a list of significant contributing industries on this basis requires direct contact with industry, and detailed analysis or evaluation of each plant's wastewater.

Once a preliminary list of possible MCI's and other significant industries has been developed, each major contributor should be classified into the proper Standard Industrial Category (SIC). This may be accomplished by matching the industry's products or commercial activities to the SIC codes as listed in the Standard Industrial Classification Manual published by the Executive Office of the President; Office of Management and Budget. Depending on the size and resources of the municipality or authority, the MCI's might be required to self-monitor their effluent to provide the Section IV analytical information. If the municipality has the resources, it may elect to do analytical surveys on its own. Once the Section IV reports have been completed, the municipality can then use this information as a data base for the development of ordinance stipulations, including compliance requirements and user charge fee schedules.

Scheduled Monitoring

Scheduled monitoring involves the systematic sampling and inspection of significant industrial contributors to the POTW system in accordance with a predetermined schedule. The schedule should be developed by the POTW personnel administering the industrial pollutant control program, and should be maintained as confidential information so that the industries in the system are unaware of contemplated monitoring visits well in advance of their occurrence. Notification is necessary, however, prior to the visit when the sampling point is located on plant property, to arrange for required utilities and proper access to sampling areas. The schedule should attempt to provide for the monitoring of each significant industrial contributor at least once per year if at all possible. If resources do not permit this type of coverage, then visits should be planned as often as possible within the limitations of available resources.

Scheduled monitoring should serve a number of specific needs, including: (1) checking for compliance with the ordinance, (2) user charge and industrial cost recovery determinations, and (3) completion of required EPA reports. Scheduled compliance monitoring should be aimed at obtaining all the information necessary to determine adherence to the local ordinance. The information required for user charge and capital cost recovery coincides to a large degree with the data necessary for the completion of required EPA reports. In addition to the Section IV forms, many NPDES permits require the municipality to furnish the EPA with periodic reports on the progress of industrial contributors toward compliance with pretreatment regulations. Also, if the POTW is the recipient of Federal construction grant funds, it is required by Federal regulations to review user charges on an annual basis. This review would usually require that the municipality monitor the quality and quantity of major industrial contributors. Even if the municipality has not been granted Federal funds, a periodic review of user charge fees is usually needed to keep abreast of changing conditions in the system.

The three elements of scheduled monitoring outlined above (compliance, user charge and EPA reports), although designed to meet differing needs, all require a similar field effort and technique. All three should be conducted on a reasonably rigorous basis to assure the validity of the data obtained. Each element of scheduled monitoring should provide for a single visit to a specific industrial facility for the duration of time necessary to obtain all data required for the purposed indicated above.

In general, scheduled monitoring would include on-site inspection of pretreatment facilities and plant operations, and composite samples and flow measurements taken over a period of several days. On-site inspection is necessary to insure that pretreatment facilities are being operated properly and to detect any dilution of plant wastewaters. The determination of flow is important for several reasons. Primarily, flow information is essential in the calculation of user charge fees. Additionally, flow readings are necessary as an added safeguard against dilution and to confirm the validity of concentration measurements taken for ordinance compliance. The degree of care and conformance to established procedures in obtaining samples and flow measurements during scheduled monitoring visits is an extremely important consideration. Information obtained during this process may ultimately be used in enforcement activities culminating in court action. Additionally, in the determination of user charges, the municipality may be compelled to monitor with sufficient rigor to satisfy the industry that the information obtained is sufficiently accurate. This situation is especially valid in those cases where sewer use charges are a significant expense for the industry.

Although detailed composite sampling may be most desirable for compliance monitoring, simple grab samples may often be sufficient to determine ordinance compliance. It is recognized that many POTW systems do not have sufficient resources to monitor each significant contributing industry once per year for a period of several days. The essential aspect is to obtain a sample that will have sufficient validity should it become necessary to use the data for enforcement activities. The applicability of less rigorous sampling, such as simple grab samples, depends largely on the stipulations of the ordinance concerning sampling technique and the municipality's ability to enforce the ordinance using the data derived from a grab sample.

Unscheduled Surveillance

In addition to the planned approach, POTW's should institute a less formal type of compliance monitoring designed to provide a spot check of industrial contributors. This random type of compliance monitoring should be focused on maintaining a degree of surveillance, and would generally not be formally planned by the POTW.

Scheduled compliance monitoring is designed primarily to establish the characteristics of contributions from major sources, whereas unscheduled surveillance attempts to randomly survey all sources within the system. By checking all contributors over an extended period of time, the municipality can continue to expand its data base, and keep abreast of trends and changes within the system. This type of monitoring should be conducted on a random basis, with contributors being observed during normal operation, thus providing information on the true nature of the wastewater. If ordinance violations are suspected, the information obtained during unscheduled surveillance can also be used to evaluate the need for further, more detailed, evaluation of a particular contributor.

Unscheduled surveillance can be conducted with less rigor than scheduled compliance monitoring. Since surveillance activities are intended only to provide a quick spot check to determine the need for future more detailed analysis and evaluation, this type of monitoring can be less formal than a full compliance monitoring visit. Unscheduled surveillance should involve no more than a few samples, perhaps composited over a short period of time, and a cursory inspection of plant operations and pretreatment activities. Where resources are limited, grab samples are frequently used for this type of surveillance. Flow measurements should be taken if facilities are available to obtain readings without difficulty.

Demand Monitoring

As the name implies, demand monitoring should be conducted when an upset or other disruption of system operation occurs, which may have been caused by an industrial source. Additionally, any discharge of prohibited or limited materials can prompt demand monitoring. Specific occurrences that may initiate a demand monitoring sequence are as follows:

1. Contributions of Explosive or Corrosive Materials to the Sewer

Release of these types of materials are generally prohibited by the municipal ordinance. Because of the magnitude and immediacy of the potential impact of explosive or corrosive materials, swift location of the source is essential. The most effective means of locating sources of explosive or corrosive materials is by utilizing sewer back tracking, which is a systematic search upstream through the sewer system until the source is pinpointed.

2. Operating Difficulties

Treatment plant and collection system operating difficulties can also prompt demand monitoring. One of the more serious operating problems is caused by the release of materials into sewers which can cause blockages or plugging. Similarly, excessive quantities of viscous or floating solids entering a treatment plant can disrupt unit operations such as sludge digestion. The presence of excessive foaming can also cause operating difficulties, and may prompt a demand search. In general, any upset of normal operating routine may be considered cause for initiating demand monitoring.

3. Violation of the POTW's Permit Requirements

A POTW's permit generally contains limits on the concentrations of specific pollutants that it can discharge to navigable waters. If the treatment process is disrupted to the extent that these limits are exceeded, it becomes the responsibility of the municipality to determine the source of the materials that might be passing through the system, or causing poor removal of the pollutants that the treatment system is designed to remove.

4. Violation of Pretreatment Regulations

Since many NPDES permits require the development of an ordinance that contains requirements for compliance by MCI's to pretreatment regulations, a suspected violation of these standards can initiate demand monitoring. In such cases, demand monitoring should provide information on the cause of interferences, and the responsible party. In these situations, demand monitoring can be most successful when the municipality has access to a good data base. Using data base information, the probable sources of interfering materials can generally be determined and monitored so that responsibility can be properly assigned.

It should be noted that in those cases where demand monitoring is prompted by the presence of an explosive material, the removal of the explosion hazard must have top priority. It is unwise to attempt sewer backtracking until any possible danger has been eliminated.

Self-Monitoring

Many of the monitoring activities that have been outlined in the preceding paragraphs require that samples be taken at the effluent of an industrial contributor, and analyzed for appropriate pollutant parameters. Depending on the available resources and manpower, the municipality may not be able to perform all of the various monitoring functions required for industrial contributors. At a minimum, the municipality should attempt to conduct, with their own personnel, compliance and demand monitoring activities for all significant industrial contributors within the system. However, complete coverage of all contributors within the system may be more difficult to implement using municipal personnel and resources. One way to circumvent this problem is to require each major contributor to do its own sampling and analysis, a function which is usually termed self-monitoring.

Self-monitoring systems require that a mechanism for reporting and record-keeping be maintained by the industrial establishment. Periodic reports would generally be sent directly to the municipality. The recordkeeping function permits access to a history of source quantity and quality which can aid in both data base development and compliance determination.

Self-monitoring can be particularly helpful in the development of the initial data base. Forms can be forwarded to industrial contributors requesting information on the flow and pollutant characteristics of their effluents. This type of approach is most applicable where a local permit program is utilized, and the form then becomes a permit applicaton. Data accumulated in this manner can serve as the basis for establishment of an industrial pollutant control program, with verification achieved through subsequent compliance monitoring.

Enforcement

An important function of a monitoring program is its ability to provide specific information required by enforcement activities. Enforcement implies that there has been a violation of a regulation. In general, municipalities will use monitoring information to assess deviations from ordinance stipulations. If conducted with the proper rigor and quality control, wastewater sampling and analysis previously performed by the municipality can be used in enforcement activities directed at ordinance violators. Self-monitoring information generally is not used for enforcement. If an industry is aware that its contribution is in violation of the ordinance, it is not likely that it would be willing to submit such data to the municipality for use in enforcement proceedings. Therefore, self-monitoring data should not be considered suitable for enforcement activities. Instead, the municipality should rely on its own monitoring information, legally obtained, with proper technical execution.

Field Considerations in Monitoring

Background

Organizational and managerial aspects of a monitoring program may vary considerably from system to system, but the approach to the technical problems encountered in any field monitoring activities remain fairly constant. The need to maintain rigor and objectivity dictates that sound, uniform and well defined procedures be maintained during plant investigations and sampling programs. Some guidance on how to develop and carry out a monitoring program is available in an EPA Technology Transfer document entitled "Handbook for Monitoring Industrial Wastewater." This handbook describes technical aspects of monitoring, but its major emphasis is directed at industries discharging directly to navigable waters that are engaged in self-monitoring activities. Although many of the details remain the same, field considerations for monitoring industrial contributors in a pretreatment situation have a slightly different orientation. Special field considerations for monitoring pollutants introduced into POTW's are outlined in this section.

An ordinance will generally prohibit, or set limits on the release of specific materials to the municipal wastewater treatment system. Wastes that cause an explosion hazard, or block or corrode the sewer are generally completely prohibited. Other pollutants that may either inhibit biological processes, or pass through the system, may be limited by ordinance. It is therefore essential that the monitoring program supply data on the contributions of prohibited and limited substances as stipulated in the ordinance. Furthermore, the ordinance may establish the frequencies and the type of sampling required for non-residential contributors. Monitoring activities must also be coordinated with these aspects of the ordinance.

The approach to monitoring in the field subdivides into three basic categories: (1) Monitoring on a scheduled and planned basis, (2) Unscheduled surveillance on a random basis, and (3) Demand monitoring prompted by an emergency condition or violation of standards. Field considerations in plant sampling during a planned visit or random visit for unscheduled surveillance are similar in many respects, although less rigor is required during an unscheduled visit. Consequently, details on the field aspects of monitoring have only been provided for scheduled and demand monitoring, since the information provided under scheduled monitoring may generally be used as a guide for unscheduled surveillance.

Scheduled Monitoring

Scheduling

An attempt should be made to systematically cover all significant contributing industries annually if resources permit. After initial data base development, monitoring should be conducted at each major contributor to determine progress toward compliance. Once compliance is achieved, the contributor must be sampled periodically to assess continued compliance. Additionally, when a scheduled compliance monitoring visit uncovers a violation, scheduling should be altered to provide more detailed analysis of the wastewater. This extended sampling program is normally required to obtain data sufficiently valid for enforcement activities.

In all cases, the frequency and order of investigations should be determined on the basis of size and importance of the contributor. Sampling should be started with the largest, or most significant industry. Once the major industries are covered for data base and initial compliance purposes, a continuing program of follow-up monitoring should be instituted. It may not be within the resources of the municipality to cover all contributors within its system thoroughly and equally. A schedule in which major contributors are monitored more frequently than minor contributors will generally be necessary.

Preparation for a Monitoring Visit

Industries should not be notified well in advance of scheduled monitoring or unscheduled surveillance visits. It is generally agreed that by not giving prior notice to the industry, the samples that are obtained will be more representative of daily operation. Nevertheless, notification just prior to the visit is necessary when the sampling point is located on plant property, to allow for necessary utility and access arrangements by plant personnel.

Prior to sampling at a contributor, the sampling crew or inspector should obtain specific information about the industry. During the initial visit a plant inspection report should be prepared. Several specific items should be included in this report:

- --A sketch of the location of all wastewater effluent lines that flow into the publicly owned sewer system. The sketch should also include the layout of major plant features.
- --A description of major product lines and processes utilized within the plant. For MCI's this information may be obtained from the Section IV report.
- --A detailed description and appropriate sketches of existing pretreatment facilities, including operating data if available.
- --A list of pollutants of interest at the plant, with emphasis on materials limited or prohibited by the ordinance.

Equipment

On-site inspection, flow measurement and sampling should be accomplished during each visit. Accurate flow measurement and sampling techniques are of prime importance in obtaining valid monitoring information. Both flow measurements and sampling can be accomplished either manually or through the use of automatic devices. Three types of sampling may be utilized:

--Grab samples, in which a single volume of wastewater is obtained and analyzed. This type of sample will not always provide an accurate measure of wastewater characteristics, especially when the flow is heterogeneous, or varies with time.

--Simple composite sampling is a timed sequential collection of equal volume grab samples that are combined in a single reservoir. This type of sample can give a partial evaluation of the variability of wastewater composition with time. It does not provide any measure of the total pounds of pollutant discharged since pollutant loading is a flow related value.

--Flow proportioned composite samples are obtained by collecting incremental samples with volumes proportional to flow. This type of sample, when analyzed and compared to total flow,provides the most accurate measure of wastewater quality and pollutant loading.

Automatic sampling devices that can obtain all three sampling types are commercially available. These automatic samplers vary over a wide range in cost, applicability and reliability. Two EPA documents are available which provide thorough evaluation of commercial automatic samplers:

--"Sampling of Wastewater," by Philip E. Shelley
Available through EPA Technology Transfer

--"Wastewater Sampling Methodologies and Flow
Measurement Techniques"
EPA Report 907/9-74-005

The second document also includes information on the performance of portable automatic flow measuring devices. There are considerably fewer devices of this type on the market than automatic samplers. However, a few portable instruments are available that can provide reasonably accurate flow measurement data.

For the smaller system, or those municipalities that have only limited resources, both sampling and flow measurement may be accomplished using manual techniques. All three sample types can be collected using manual methods. In general, there is little equipment commercially available for manual sampling. What is usually needed is an extendable pole, with a stoppered bottle attached to the end. This type of sampling pole can be easily fabricated. The sample bottle should be hinged so that it can be tilted to align parallel to the wastewater flow. This orientation allows for sampling from very shallow streams. The bottle stopper should be attached to a string so that it can be removed while the sample bottle is submerged.

With regard to flow determination, the accuracy of any flow measurement depends greatly on the control surface utilized. Some ordinances may require that major contributors install a special control manhole designed to provide sufficient access for sampling and an appropriate control surface for flow measurement. Depending on the situation, permanent flow recording equipment may also be required. The installation of a standard weir or flume makes flow measurement a simple matter of measuring wastewater depth. No control surface is completely accurate, but the combined use of a quality automatic flow mesuring device and a control surface can typically yield flow measurement accuracy of better than ± 15%.

Special attention should be paid to the accuracy of sampling activities. Whereas flow measurement accuracy can be held to the 15% level, sampling errors can range up to 200% of the true value. The basic problem results from the fact that the typical industrial waste may have a large proportion of its pollutants in the form of suspended solids. As a result, it is important that the quantity of suspended solids entrained during sampling be proportional to the suspended solid content of the total wastewater stream. Common practice is to simply place a suction tube in the wastewater flow, or to immerse an open sampling bottle in the stream. Since solids entrainment is a velocity controlled process, an attempt should be made to obtain samples isokinetically. There should be a minimum fluid velocity difference between the interior and exterior of the sampling tube. Accomplishing this type of sampling is a difficult procedure, but the situation can be significantly improved by aligning the sample tube such that it is facing upstream and is secured rigidly in place. Because of the potential for large errors associated with sampling, it is essential that extreme care be exercised in selecting sampling devices and procedures.

Sample Handling

Once an accurate sample has been obtained, several steps should be taken to assure that the validity and objectivity of the monitoring operation is maintained. All samples must be properly preserved. Sample preservation techniques are outlined in various analytical handbooks such as Standard Methods and the EPA Chemical Methods Manual. The content of these and other similar handbooks are discussed in more detail in the section devoted to laboratory considerations in monitoring.

Because of the heterogeneous nature of many industrial wastewaters, the parameters to be analyzed may require the use of incompatible stabilizing reagents. To solve this problem, it is usually necessary to take a relatively large volume of sample, so that it may be divided for appropriate preservation. In addition to assuring adequate volume for sample preservation, sufficient sample size must be maintained so that a portion of the sample can be offered to the industrial contributor. The option should be given to the industry of independently checking the municipality's analytical results if they so desire.

Chain of Possession

Once an appropriate sample is obtained and properly stabilized, it is essential that the possession of the sample be properly documented. That is, the person completing the field sampling should maintain a log, containing pertinent information such as date, time and location of the sampling activity. Before releasing the sample to the laboratory, or any other appropriate official, a signed receipt should be obtained documenting the exchange. As the sample is transported, a continuous history of its condition and locations should be maintained through successive log entries and receipts.

The reason for such caution in the handling and transfer of samples stems from the need to be certain of sample integrity as part of any enforcement activity. It should be assumed that every scheduled compliance monitoring sample may become evidence in a court of law. In practice, few ordinance violations will require legal action, but nevertheless, sample integrity must be maintained. If the municipality cannot prove that a sample has not been mishandled or tampered with, then any inferences regarding the quality of the wastewater that the sample represents fall into jeopardy. It is therefore essential that a chain of possession be maintained and recorded.

On-Site Safety

Visitors to industrial establishments are usually required to abide by any safety regulations observed by plant management. Ideally, access to wastewater flows should be available from manholes or junction boxes located outside of plant property. In this way, plant inspectors would not be exposed to any hazardous operating activities and would be able to sample without the need to gain entry to the plant. Unfortunately, accessible manholes located outside of plant boundaries are rare, and consequently inspectors are generally required to enter upon plant property. Under these circumstances, all pertinent safety rules in force at the plant must be adhered to. The first step upon presenting credentials and entering the plant, is to notify appropriate plant management, and request applicable safety information. In most cases, a formal set of safety rules are in effect, and these rules should be recorded and filed with the plant inspection report.

Minimum safety equipment that must be carried by each inspector or inspection crew includes:

--Hard Hat
--Safety Goggles
--Rubber Gloves, Boots and Other Protective Clothing
--First Aid Kit

Special safety precautions and equipment are necessary for any sampling activity that requires manhole entry. The most dangerous aspect of sewer sampling and inspection is the possible presence of dangerous gases in sewers. These gases may include either explosive vapors or poisonous mixtures. Conversely, there may be an oxygen deficiency in the sewer. In order to avoid possible injury, several precautions should be taken and proper equipment should be utilized during the course of sewer inspection as follows:

--Manholes should be opened with a hook rather than a pry bar. Using a hook reduces the possibility of having metal rub against metal, causing a spark and possible explosion.

--Before entering a manhole, the atmosphere within the sewer should be tested for oxygen content, explosion hazard and poisonous gases. Several portable, probe type oxygen and explosion meters are commercially available. Equipment of this type should be utilized during every sewer entry. Many types of indicating ampoules and gas detection test kits are available which can signal the presence of poisonous gases. A

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complete set of such test materials must be present and utilized during each sewer inspection.

--Appropriate gas masks and breathing mask respirators should be used whenever there is the slightest indication of danger.

Actual entry into a manhole requires additional special safety precautions. Although nearly all manholes are built with ladder rungs, these rungs may have been used infrequently. As a result of the often corrosive atmosphere in a manhole, it is not advisable to use sewer ladder rungs, since it is possible that they may not be structurally sound. Descent into a manhole should be accomplished utilizing a portable rigid ladder or flexible rope ladder. Even when a ladder is used, each individual entering a manhole should be harnessed with a safety rope leading to the surface. In this way, in the event of a fall, asphyxiation or other injury, the individual can be pulled to the surface with relative ease.

Fire safety should always be practiced whenever within an industrial plant or near an open manhole. No open flames should be permitted, and all equipment should be explosion proof and water resistant. Since many manholes are located on streets or other thoroughfares, additional safety precautions should be taken to avoid automobile accidents and the possibility of pedestrians falling into open manholes. Consequently, appropriate pylons, barricades and flashing lights should be used in the vicinity of the manholes.

Equipment Set-Up and Field Analysis

In the absence of a control manhole equipped with brackets or ledges for mounting automatic samplers and flow measuring devices, a method must be devised for securing and mounting equipment. Within the boundaries of a plant some degree of security can be assumed, but unattended sampling points in public areas can be tempting to vandals. One solution to this type of field problem is the use of a self-contained trailer or van outfitted with appropriate materials and equipment. A further advantage to using a monitoring vehicle is that the time required for set-up and removal of equipment is greatly reduced. Furthermore, the vehicle can be outfitted with appropriate field analytical equipment. Certain parameters require immediate analysis upon sampling, such as dissolved oxygen and pH. Equipment for these analyses can be mounted in the vehicle to facilitate rapid analysis.

For the small system, resources may not be available, nor the need apparent, for a sophisticated well equipped monitoring vehicle. At the very least, a compact package containing necessary equipment should be utilized. A minimum number of separate equipment packages should be maintained, with the dimensions of a foot locker being an ideal size for each equipment carrier.

Continuous On-Line Monitoring

In recent years, equipment has been developed which can automatically monitor various wastewater characteristics. For industrial wastewaters, numerous constituents may be of interest. However, as a result of operating difficulties, generally only a few parameters can be successfully analyzed on a continuous basis. The sensors typically used in automatic monitoring equipment are often very sensitive to interferences found in wastewater, and as a consequence great care should be exercised in choosing this type of specialized equipment. Because of the commonly encountered operating difficulties, continuous on-line monitors generally require a high level of maintenance and attention. If the equipment works well, it can serve as an excellent source of continuous data which will not only aid in wastewater and process operation evaluations, but through the use of auto punching can also reduce the amount of manual handling of data. Various manufacturers offer continuous on-line analytical equipment which can provide excellent monitoring information. However, it should be noted that automatic analysis is still a developing technology, which should be approached with an appropriate degree of caution.

Demand Monitoring

Unlike scheduled monitoring in which a planned and orderly approach can be maintained, demand monitoring results from emergency conditions occurring on a random basis. As outlined under the functions of a monitoring program, specific emergency conditions can prompt a demand monitoring sequence. These situations include:

--Explosion Hazard
--Slugs of Inhibitory Materials
--Plant Upsets
--Sewer Blockages
--Violations of the POTW's NPDES Permit
--Any danger to public health or safety

For demand monitoring, rapid initial detection and prompt location of the violator are essential. To facilitate detection it is advisable where possible that permanent continuous surveillance stations be established at key points throughout the collection system. As soon as an abnormal wastewater quality or flow rate is detected, either at the treatment plant or at some point in the collection system, an immediate investigation should be initiated. This investigation should be systematic, back tracking in the sewer until the source of the violation is located.

As a result of the transient nature of many violations, it is essential that analytical work done in the course of sewer back tracking be completed rapidly. Presence of a prohibited or limited material in a trunk sewer cannot be used as evidence that a specific industry is the source of the problem. As a result, it is advisable to use quick spot-check methods during back tracking operations. The object of the procedure is to isolate the pollutant in question in a lateral sewer in which a particular industry is the only contributor. Once the source of the problem is located, then rigorous analytical techniques should be utilized to facilitate possible enforcement activities.

Laboratory Considerations in Monitoring

Once an administrative approach, and technical methodology are developed for obtaining industrial wastewater samples, a mechanism for accurate and rapid analysis of the samples must be provided. It is essential that analytical results be accurate and reproducible to assure that monitoring activities will provide the quality of information necessary for a successful industrial pollutant control program.

Standard Analytical Techniques

Precise and well recognized techniques have been established for the analysis of wastewaters. EPA has promulgated rules and regulations on this subject entitled "Guidelines Establishing Test Procedures for Analysis of Pollutants," dated October 15, 1973 with a proposed revision dated December 1, 1976 (Appendix 3). These rules stipulate specific analytical methods that are recommended by EPA for the determination of 115 chemical and biological parameters as reported in three analytical handbooks. The three referenced manuals are:

--"Manual of Methods for Chemical Analysis of Water and Wastes." available through EPA Technology Transfer

--"Standard Methods for the Examination of Water and Wastewater," published by the American Public Health Association

--"Annual Book of Standards, Part 31, Water, Atmospheric Analysis, 1975," published by the American Society for Testing and Materials (ASTM)

Each of these documents provides a short synopsis of the analytical method for each parameter, information on interfering substances, and step-by-step instructions on how to carry out the analysis. Also included is information on the calculation of results, the precision and accuracy of the analytical method, and techniques for chemically stabilizing and preserving samples.

These three publications should be considered a minimum requirement for any analytical laboratory. These manuals and handbooks supply the basic information that a trained lab technician would need to successfully perform nearly all analytical procedures that may be required in connection with monitoring programs.

Analytical Quality Control

The potential errors encountered during analysis of wastewater samples, although not as great as the errors associated with poor sampling techniques, can nevertheless have a great impact on the acceptability of monitoring information. Without the aid of independent checks and general quality control, the lab technician can report erroneous results without being aware that a problem exists.

Analytical quality control assistance is available in several forms from EPA. A document entitled "Handbook for Analytical Quality Control in Water and Wastewater Laboratories," has been published by the EPA Technology Transfer Program. In this handbook, specific information is provided that can guide the lab technician or chemist toward sound and reliable techniques and procedures. In addition, standard approaches to data handling and reporting, and information on calibrating equipment are included.

The EPA "Manual of Methods for Chemical Analysis of Water and Wastes" also includes information pertinent to laboratory quality control. Each of the ten EPA regional offices has an office of Analytical Quality Control headed by a Regional Analytical Quality Control Coordinator.

Included in the EPA Methods Manual are a listing of the ten Quality Control Coordinators, accompanied by appropriate addresses and telephone numbers. Through the Quality Control Coordinators, any interested party can obtain preanalyzed samples that can be used to test the accuracy of analytical techniques. Periodic analysis of known samples can provide the lab technician with an independent check of his accuracy, providing the opportunity to correct any improper procedures.

Equipment

A document entitled "Estimating Laboratory Needs for Municipal Wastewater Treatment Facilities" published by the Operation and Maintenance Program of the EPA Office of Water Program Operations, provides specific information on the minimum requirements for laboratory facilities at various sized wastewater treatment plants. This publication also includes recommendations on how a laboratory operation may be altered to handle the analysis of pollutants contributed by non-residential sources.

Laboratory equipment required for a municipal wastewater treatment plant is generally standard, with variations occurring only in degree, as the size of the plant varies. If, however, a publicly owned system receives wastewater from a particular industry, specialized analytical equipment may be required. The range of applicability of several special types of equipment are discussed in the following paragraphs.

Atomic Absorption

Atomic absorption spectrophotometry provides a rapid and easily performed technique for the analysis of metals in wastewater. Nearly all of the more than thirty elements that can be analyzed by atomic absorption, can be analyzed by standard wet chemical techniques. However, the wet chemical methods can be tedious and time consuming, requiring detailed sample pretreatment procedures. Atomic absorption methods provide for metal analyses with minimum sample preparation and, in many instances, analyses can be completed to the parts per billion level, which is not attainable with standard wet chemical techniques.

In some respects atomic absorption does have limitations. In all cases, atomic absorption provides only the total concentration of the element. Unless specialized pretreatment is utilized, no breakdown of oxidation state or ionic species can be determined. However, for the analysis of metals at very low concentrations, atomic absorption is unsurpassed in speed and accuracy. In situations where a large number of metal analyses may be necessary, such as those POTW's that receive wastewaters from metal processing or finishing industries, atomic absorption capabilities may be required. But in all cases, the relatively high cost of atomic absorption equipment should be weighed against the need for high volume trace metal analysis.

Specific Ion Electrodes

Specific ion electrodes are sensing probes that can detect the concentration of chemical species when immersed in a solution containing the substance to be measured. As long as the probe is completely submerged, a concentration can be measured regardless of the volume of sample present. In contrast to atomic absorption, specific ion electrodes, as the name implies, detect only certain ionic species as they exist in solution. As a consequence, specific ion electrode readings are greatly dependent on the environmental conditions within the sample, such as pH and oxidation-reduction potential.

More than two dozen ionic species can be analyzed using specific ion electrodes. Analyses are rapid, but require some pretreatment to remove interferences prior to simple immersion of the probe in the sample and meter readout. The drawbacks to this type of specialized equipment include possible fouling of the probe membrane, long readout equilibrium periods and the ability to detect only specific ionic species. However, progress is continually being made in ion sensing electrode technology. Excellent use has been made of the commercially available dissolved oxygen probes for measuring oxygen demand, and an ammonia sensing electrode has been successfully used for monitoring nitrification in an activated sludge treatment plant. Because of the potential ease and speed of analysis that can be realized with specific ion electrodes, consideration should be given to the possible use of these methods for selected ionic species.

Automatic Analyzers

A few manufacturers currently market automated wet chemical analyzers that are typically called automatic analyzers. These devices automatically draw a small sample, add pretreatment chemicals, filter the sample if necessary, add chemicals to develop a color with an intensity proportional to the concentration, and finally automatically read and record the concentration proportional to the developed color. Other more sophisticated automatic analyzers may use infrared or ultraviolet spectrophotometric detection, and some use fluorometers or flame photometers. In effect, the typical automatic analyzer eliminates the steps that a technician would have to perform in carrying out typical wet chemical analysis.

Although an automatic analyzer can greatly reduce the time required to perform a particular analysis, use of these instruments is only economical when the analysis is required on a mass production basis. Furthermore, automatic analysis instruments are relatively complex devices that can require a substantial maintenance effort. As indicated for the other specialized equipment described in this section, automatic analyzers should only be used when the presence of a specific pollutant contributed by a particular industrial source is so important that frequent analyses are required.

Gas Chromatography

Gas chromatography refers to several variations of a technique in which a wastewater sample is vaporized, and the organic fraction is then analyzed. Gas chromatography is by far the most efficient way of analyzing for trace organics in wastewater, especially pesticides. However, most gas chromatographs are relatively expensive and require highly skilled operators. As a result, this type of equipment finds only limited application in POTW analytical laboratories.

IR-UV Spectrophotometry

Infrared (IR) and ultraviolet (UV) spectrophotometers, like gas chromatographs are used to analyze for organic materials in wastewater. UV spectrophotometry has been used recently for detecting oil and grease in wastewater samples. However, these two types of specialized equipment generally have only limited and specialized uses because of cost and the requirement for skilled operators.

Personnel and Degree of Expertise

Laboratory manpower requirements are outlined in the Operation and Maintenance Program document "Estimating Laboratory Needs for Municipal Wastewater Treatment Facilities." Some quantitative information is provided for determining how laboratory manpower should be altered to handle non-residential contributions. Although a thorough general analysis is provided in the publication, it should be noted that each system presents a unique situation. Nevertheless, it can be stated in general terms, that any monitoring program will require an added degree of laboratory support. For very small systems with few industrial contributors, the additional analytical work can probably be handled by the technician performing regular sanitary chemistry. Larger systems may require the addition of personnel to handle the greater load created by the industrial monitoring program.

If analyses in connection with the monitoring program require the use of any of the specialized analytical equipment outlined above, technicians or chemists with more than the usual level of expertise may be required. Although the utilization of specific ion electrodes is relatively simple, proper use of atomic absorption, automatic analyzers, gas chromatographs or IR-UV spectrophotometers does require a higher degree of expertise. Automatic analyzers and atomic absorption require good technique, and special attention to equipment maintenance. In order to properly utilize either gas chromatography or IR-UV spectrophotometry, special technical expertise beyond the 4-year college level may be required.

Special Analytical Considerations

Underlying the compliance and enforcement uses of analytical data is the need to know the true composition of wastewater contributions so that the presence of harmful materials can be detected. In general, EPA recommends that wastewater samples be stabilized in a manner that will solubilize otherwise insoluble, or suspended materials. This is an especially important factor in the case of metals which are generally insoluble at high pH levels. Metal concentrations are of particular interest to plant operators since relatively small quantities of these materials can cause operating problems. However, the metallic pollutant generally must be in solution before it can cause an upset of biological treatment processes. As a result, the practice of acidifying samples and obtaining total, rather than dissolved metal concentrations can give misleading results for samples with high pH levels. Metallic pollutants at high pH values would tend to be in the form of suspended solids, and would most likely be substantially removed prior to reaching biological treatment facilities. Consequently, the impact of a wastewater stream can greatly depend on the pH of the wastewater as it enters the treatment system.

Another similar example is the importance of the oxidation state of the constituent being measured. For example, hexavalent chromium is generally considered to have a greater impact on biological treatment processes than trivalent chromium. The impact of hexavalent chromium can be significant, but the typical environment in a sewer system would tend to reduce this material, and often ensure that only trivalent chromium reaches the treatment plant. Clearly, the analysis of wastewaters containing materials having various impacts which depend on the conditions in the sample, must be approached prudently, considering the state of the pollutant as it enters the treatment system.

Correlation of Analytical Techniques

In determining compatible pollutant loadings, it is necessary to analyze industrial wastewater contributions for the typical oxygen demand parameters. BOD historically has been used to measure oxygen demand, but this test is time consuming and can be inaccurate. COD has been used in place of BOD, but it too can be tedious, and it also takes a significant amount of time to complete. In recent years, catalytic oxidation approaches have been developed that yield measures of oxidizable substances that can be correlated to the more standard BOD or COD tests. These analyses, which are termed total organic carbon (TOC) and total oxygen demand (TOD), are rapid and reproducible.

A large body of data has been developed showing that the more rapid TOC and TOD methods can be correlated to BOD, and therefore can act as a more efficient measurement tool for an operating facility. Other similar correlations can be developed that can increase the efficiency of laboratory operations. For example, oil and grease is usually measured by an extraction gravimetric technique. This measurement can be simplified or accelerated by utilizing a UV spectrophotometer to detect the levels of organics if this type of device is available. Substitutions of methods that are either faster, more accurate, or encompass a broader range of parameters should be considered for unofficial use, when they can be correlated to standard methods.

Standard Reporting Procedures

Laboratory data handling and reporting require two basic considerations; reliable methods for recording both laboratory and field data, and criteria for determining the significance and acceptability of the data. Without a good system in which standard procedures are used for accurate recording of analytical and field data, the usefulness of the information obtained from monitoring operations can be greatly diminished. Standard forms should be developed for recording field information, which would include the conditions at the time of sampling. All laboratory data should be recorded in bound notebooks with numbered pages. This assures a continuity in time, with a sequence for all analytical data. All forms should be completed in duplicate, with each copy being stored separately as a precaution against accidental loss of data.

Of equal importance to proper recording methods is the significance and acceptability of data collected. One must be certain that the sample being analyzed is representative, and has not been influenced by infrequent or rare laboratory or plant occurrences. Numerous statistical techniques are available that can provide a measure of the appropriate confidence that should be assigned to the data. These statistical techniques are adequataly covered in several of the handbooks cited above. However, caution should be exercised when using statistical methods. Generally, statistics offer a means by which variations in a set of data can be analyzed, assuming that all of the data used in the analysis is equally valid. Although statistics can be a powerful tool, it is always preferable to evaluate the significance of data variation on the basis of first-hand knowledge of the situation during sampling and analysis. Many times, if unusual circumstances are apparent, the data can be eliminated from consideration by inspection, and the problem can be rectified without the use of more sophisticated statistical analysis.

Contracting for Analytical Services

Many of the considerations discussed above concerning laboratory aspects of a monitoring program are based on the assumption that a POTW either has an existing laboratory which will be expanded to handle industrial wastewater, or has the resources to develop such facilities. This may be true for the larger systems, but the more numerous small systems may not have the resources or capability to complete the necessary analyses required for proper monitoring of industrial wastes. In such systems, analytical work must frequently be performed by commercial laboratories. When choosing a laboratory several criteria should be considered to assure that proper services are being provided.

At the present time only a few states have developed a certification system for commercial laboratories. EPA is currently in the process of developing a guidance document for lab certification programs. As a result, for the short term,POTW's wishing to engage qualified laboratory services will be required to evaluate laboratory performance independently. For the long term, use may be made of the upcoming guidance to be supplied by EPA.

Several techniques can be used to compare the quality of analytical services provided by commercial labs:

1. Use of samples spiked with known amounts of pollutants of interest. Chemicals used in the spiked samples can be obtained from the

appropriate EPA Regional Quality Control Coordinator. Use of spiked samples is a desirable method for testing laboratory performance when analyzing complex wastewater mixtures.

2. Parallel analysis of identical samples at two or more commercial labs. This procedure can provide information on the relative performance of the laboratories in question.

3. Adherence to standard procedures is essential, and as a result should be used as a primary criteria for evaluating lab performance.

4. Competitive costs are also important, providing that an acceptable quality of analytical services is provided.

Conducting an Industrial Waste and Pretreatment Survey

EPA's Office of Research and Development has published a case study titled "Industrial Waste and Pretreatment in the Buffalo Municipal System" (EPA 600/2-77-018) which includes a comprehensive description of how to organize and conduct an industrial waste and pretreatment survey. This document provides an excellent framework for municipalities wishing to gain detailed information concerning the mechanics of conducting an industrial survey. It is recommended that the reader refer to this document for further information, which is available by writing: General Services Administration, Centralized Mailing Lists Services, Bldg. 41, Denver Federal Center, Denver, CO 80225, and requesting MCD-31.

SECTION E
POLLUTANTS WHICH INTERFERE WITH PUBLICLY OWNED TREATMENT WORKS

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SECTION E
POLLUTANTS WHICH INTERFERE WITH PUBLICLY OWNED TREATMENT WORKS

Introduction

Interference with the operation of a POTW system can be caused by a wide variety of chemical, biological and physical phenomena. In a broad sense, interference consists not only of materials which inhibit biological sewage treatment processes, but also substances which cause problems in sewage collection systems, sludge disposal or utilization methods, water reuse, land application of wastewater or other operations. Collection system problems include fire and explosion hazards, corrosion and solid or viscous wastes which cause plugging of sewers, and a discussion of these problems is included herein. Interference with sludge disposal or utilization and reuse of wastewaters consists primarily of incompatible pollutants which are concentrated in sludge or by reuse techniques.

This section of the report primarily presents technical data on the various substances which inhibit biological treatment processes, including the problems caused by the excessive discharge of pollutants to a treatment facility. Consideration was given to interference with physical-chemical sewage treatment systems, employing activated carbon adsorption following primary treatment such as chemical coagulation and filtration. Although many facilities of this type are currently being designed and constructed, operating data from full scale physical-chemical plants is extremely limited at this time. In addition, the characteristics of the activated carbon adsorption process are such that there are few substances which cause interference. Consequently, although it is recognized that physical-chemical treatment facilities will become more prevalent in the future, a detailed discussion of interference with such processes has not been included in these guidelines.

Materials Which Inhibit Biological Treatment Processes

In an effort to describe inhibitory effects, treatment processes and interfering substances have been grouped into broad categories. Three basic categories of treatment processes have been delineated, including aerobic processes, anaerobic processes, and nitrification. The aerobic processes have been further subdivided into activated sludge and trickling filter operations, while anaerobic processes consist essentially of sludge digestion. Although many currently operating biological treatment plants utilize the trickling filter process, relatively little data is available on pollutant interferences. Consequently, the information on aerobic biological treatment presented is predominantly concerned with the activated sludge process. Since both activated sludge and trickling filtration are aerobic processes, the lack of information on trickling filtration may be compensated for by cautiously drawing parallels with activated sludge data.

The general categories established for interfering substances are inorganics and organics, with acidity, alkalinity, pH, ammonia, transition metals, metals, sulfate and sulfide comprising the major components of the inorganic category. Organic substances discussed include alcohols, amines, chlorinated hydrocarbons, pesticides and herbicides, phenol, surfactants and miscellaneous organic chemicals.

Most analytical methods used for determing the concentrations of the pollutants covered in this section yield a total result, including the contribution of both the dissolved and the precipitated substances in the original sample. In most cases, a precipitated pollutant has relatively little inhibitory impact as compared to its soluble counterpart. This results from the fact that most settleable solids and a portion of the suspended solids are removed in primary treatment, and therefore never reach the potentially inhibited biological unit process. Because the insoluble fraction of a pollutant parameter will have relatively little or no effect on biological treatment processes, most investigators have conducted their tests using only dissolved pollutants. As a consequence, unless otherwise noted, the concentration of pollutants reported in this section are only for dissolved species, not the more common total value.

Whether a substance is inhibitory depends on a number of factors, including its concentration and the presence of other chemicals which have synergistic or antagonistic effects. Some substances, such as mercury, present in wastewater at a very low concentration, can disrupt one or more functions of a biological treatment system. Other substances, such as chloride ion, are inhibitory only at relatively high concentrations. Some of the special phenomena that may alter the inhibitory nature of a substance are outlined below as a prelude to the detailed discussion of specific pollutants.

Synergism

Synergism can be generally characterized as an increase in the inhibitory effect of one substance by the presence of another. Synergism, as well as its opposite, antagonism, is found to be most prevalent when considering combinations of transition metals or heavy metals. The inhibitory effects of these metallic constituents are also enhanced by acidity.

The synergistic effects of metals with acidity is understandable in terms of the chemistry of these metals. The transition and heavy metals tend to be insoluble by hydrolysis in the pH range of sewage influent. They therefore tend to precipitate or adsorb on solids, and interact with polyelectrolytes or various chemical species containing anionic functional groups. Acidity suppresses hydrolysis, and the hydrogen ion competes with the metal ion for adsorption sites on solids or anionic functional groups in solution.

Another type of synergism is encountered with cyanide or other complexing substances which are easily biodegradable. In these cases, it is possible for the microorganism to ingest excessive levels of complexed metal ion and then to destroy by assimilation the complexing substance which is shielding the microorganism from the metal ion. The result is the release of an excessive level of the metal within the organism, upsetting its biological life processes.

Antagonism

Antagonism is the opposite of synergism in that it is characterized as a decrease in the inhibitory effect of one substance by the presence of another. The most notable antagonistic effects occur with the combination of metallic and anionic pollutants. For example, several chelating agents, such as EDTA (Disodium salt of ethylenediamine tetraacetic acid) and HEDTA (disodium salt of hydroxyethylenediamene triacetic acid) have exhibited antagonistic properties with metals. These chelating agents are used in culturing microorganisms to regulate the level of metals needed to grow bacterial cultures. Bacteria thrive in culture solutions containing concentrations of these metals well into the inhibitory range, when chelating agents are also present.

Some ambiguity as to the inhibitory effects of metals on sludge digestion has been found in the literature. Part of the ambiguity can be explained by the antagonistic effect of the sulfide normally present in a digester. Sulfide ion precipitates metals, removing them from solution and consequently eliminating their inhibitory effect. In fact, this reduction in inhibitory effects by the addition of sulfide has been used effectively in restoring upset digesters to operation (E-35). Besides sulfide, other ions such as hydroxide (i.e., high pH) chromate, ferro-cyanide, phosphate, carbonate, and arsenate will tend to precipitate with metals, thereby reducing the inhibitory effect.

Acclimation

In addition to chemical factors, there are significant biological factors which must be considered to understand the inhibitory effect of pollutants. In the activated sludge process, a healthy biomass contains a broad distribution of microorganisms, including many species of bacteria and protozoa. These organisms compete for the available food, oxygen and nutrients, and grow and reproduce according to the suitability of the aquatic environment to their existence. In the absence of sufficient food, reproduction slows and the microorganisms devour each other. Whenever the environment changes due to the introduction of, or omission of a given pollutant, the opportunities for reproduction and growth of different species change, so that the relative populations of different species are altered with conditions.

Therefore, the previous history of a particular activated sludge biomass, including its distribution of microorganism populations, affects how it will respond when a new pollutant enters its environment. When a new pollutant is introduced, those species which cannot tolerate this substance fail to reproduce and grow,and tend to die off, while more tolerant species consume the food supply and grow and reproduce.

When a biomass becomes accustomed to the presence of a normally inhibitory concentration of a substance, it can be characterized as acclimated to that pollutant. Sludge digestion and nitrification do not have the same flexibility of adaptation to changing environmental conditions as do other biological processes. Both nitrification and sludge digestion are biological processes that rely on particular strains of bacteria. In the case of sludge digestion, the process proceeds in two steps,using two specific bacterial strains to achieve digestion. Nitrification is also limited to particular bacterial types. As a consequence, when adverse conditions are encountered in these processes, there is no possibility of another organism taking over for the affected strain of bacteria. Consequently, neither nitrification nor sludge digestion are readily acclimated to a new pollutant and may be easily upset when new conditions are encountered.

Significance of Data on the Inhibitory Effects of Pollutants

As a result of the chemical and biological factors which affect the inhibitory impact of a pollutant, a given concentration of that pollutant may be inhibitory to a biological process under a given set of conditions and non-inhibitory under another set of conditions. Therefore, it is not surprising that a significant amount of data in the literature are apparently contradictory, in that certain concentrations have been reported as inhibitory, while higher concentrations are reported to be harmless. In most cases, these inversions of effects with concentration are not due to errors of observation, but rather to different conditions surrounding the biological processes, such as those described.

The following paragraphs summarize the current available data on the inhibitory effects of specific substances, as well as the chemistry and occurence of the pollutant. Where applicable, special effects of each pollutant are described. Important industrial sources of many of the pollutants discussed in this section are summarized in Appendix 8 of these guidelines. Additionally, Appendix 5 contains tables summarizing the data on the effects of inorganic substances. Appendix 5 also contains graphical presentations of the data for inorganics.

Inorganic Substances

Wastewater entering a POTW may contain any combination of thousands of inorganic compounds present as major or minor constituents. Fortunately, since most inorganic substances dissolved in wastewater are present in ionic form, it is possible to reduce the number of parameters of interest to a smaller list of cations and anions which comprise these dissolved substances. In addition, a few nonionic substances must also be considered.

The cations of interest consist of the ammonium ion and various metal ions. A few metal ions; i.e., sodium, calcium, and magnesium, are prevalent in wastewaters, but are not inhibitory except at very high concentrations (about 1000 mg/l, order of magnitude). Most metal cations, on the other hand, are beneficial or non-inhibitory at very low concentrations. However, at somewhat higher concentrations (a few mg/l, order of magnitude) they become inhibitory to biological processes.

A number of metals of interest are amphoteric; that is, they may exist in solution as a cation or anion. For example, chromium may form chromic or chromous cations or the chromate or dichromate anion. Arsenic can likewise exist as arsenic or arsenous cations or arsenate or arsenite anions.

Many anions (chloride or bicarbonate, for example) are relatively compatible with biological treatment processes. Others, such as cyanide, borate, and chlorate can pose difficulties to the biological processes. A few neutral substances are important, especially ammonia and elemental chlorine.

The significant inorganic constituents which have been identified as having inhibitory effects are discussed below, in alphabetical order. A summary of the major inhibitory effects for each inorganic pollutant is given in Table E-1.

Acidity, Alkalinity and pH

The pH of a wastewater represents the relative concentration of hydrogen ions in the fluid. Although pH is frequently used to describe the acidity or alkalinity of a sample, there are fundamental differences between these concepts. pH is reported on a scale of 0 to 14, with each pH unit representing a factor of 10 in hydrogen ion concentration. A pH of 7 is considered neutral, while a solution with a pH of less than 7 is acidic, and above 7 is alkaline.

A distinction should be made between acidity and an acidic solution, and similarly between alkalinity and an alkaline solution. As discussed above, a pH of less than 7 indicates an acidic solution. On the other hand, the acidity of the solution is a measure of its capacity to maintain its pH during the addition of an alkaline solution. For example, if an acidic solution has a pH of 6 and the addition of one drop of an alkali raises its pH to 9, it has less acidity than an equal volume of another pH 6 solution that needs ten drops of the same alkali to increase its pH to 9.

Most natural unpolluted waters have a pH value near neutral (pH 6 to 8). Excess carbonic acid gas (carbon dioxide) can result in lower (more acidic) pH values, while soluble carbonates, borates or silicates may produce higher (more alkaline) pH values.

Most bacteria favor an environment of pH 6 to 8. Rare microorganism species may tolerate or even thrive in wastes of extremely low or extremely high pH, but these are not

TABLE E-1

THRESHOLD CONCENTRATIONS OF INORGANIC POLLUTANTS THAT ARE INHIBITORY TO BIOLOGICAL TREATMENT PROCESSES

POLLUTANT	CONCENTRATION (mg/l) ACTIVATED SLUDGE PROCESSES	ANAEROBIC DIGESTION PROCESSES	NITRIFICATION PROCESS	REFERENCES
Ammonia	480	1500		E-17,E-20,E-29
Arsenic	0.1	1.6		E-5,E-21
Borate(Boron)	0.05-100	2		E-5,E-9,E-44, E-128
Cadmium	10-100	0.02		E-21,E-29,E-104
Calcium	2500			E-26,E-37,E-120
Chromium (Hexavalent)	1-10	5-50	0.25	E-5,E-29,E-78, E-117,E-129
Chromium (Trivalent)	50	50-500		E-88
Copper	1.0	1.0-10	0.005-0.5	E-2,E-5,E-24, E-78,E-100,E-109,E-129
Cyanide	0.1-5	4	0.34	E-5,E-15,E-21, E-118, E-129
Iron	1000	5		A-1, E-21
Lead	0.1		0.5	E-5
Manganese	10			E-21
Magnesium		1000	50	E-26,E-37,E-100 E-120
Mercury	0.1-5.0	1365		E-21,E-28,E-70, E-118
Nickel	1.0-2.5		0.25	E-14,E-25,E-118,E-129
Silver	5			E-8,E-9,E-21
Sodium		3500		E-26,E-37,E-120
Sulfate			500	E-11,E-17
Sulfide		50		E-19,E-35
Zinc	0.08-10	5-20	0.08-0.5	E-4,E-5,E-6,E-7,E-29 E-33,E-78,E-100,E-118

Note: Concentrations shown represent influent to the unit processes in dissolved form.

significant in biological treatment systems. As a result, pH values outside this range can cause severe upsets in biological treatment processes. This is particularly true of acidic wastewaters with low pH values in relation to nitrification or anaerobic sludge digestion.

Of equal importance to the absolute pH level in wastewater is a sudden change in pH. Sudden swings of pH are always disruptive to an otherwise stabilized system. The effect of extreme fluctuations in pH in a waste stream can be overcome by collecting, storing, and mixing the variable waste mixture in a storage vessel or pond. The effluent from this pond will show less variability and consequently will respond to biological treatment more favorably.

Discharges of wastes from commercial manufacturing or processing industries may typically result in wastes ranging in pH from about 3 to 11. Wastes outside this range are rare and represent corrosive and dangerous levels.

Acidic contributions may be received from many industrial processes including metal cleaning, plating or treatment plants, manufacture of drugs and explosives, processing of photographic films, etc.

Alkaline contributions may be received from laundries, detergent manufacture, bottle cleaners (dairies, for example), textile processing and cement manufacturing.

Summary of Inhibitory Properties:

1. The activated sludge process can treat waste solutions ranging from about pH 3 to 11, provided that the pH level has been stabilized (E-51).

2. Another source states that inhibitory effects are related to temperature and were noted above pH 10 at 20°C and above pH 9 at 10°C (E-21).

3. It has been reported that at pH 4 the activated sludge process is 43% effective (E-51).

4. The sludge digestion process is extremely sensitive to pH, and deviations of pH outside the range 6.5 to 7.5 generally cause upset of sludge digestors.

Synergistic and Antagonistic Effects:

While high acidity (low pH) is generally inhibitory to biological treatment systems, the presence of most metal ions with excess acidity results in much more severe inhibitory effects. The reason for this phenomenon is that at near-neutral pH values, most transition metal ions tend to precipitate out as insoluble flocs. These ions also tend to form hydroxo-complexes at neutral or alkaline pH values, and these complexes mask the inhibitory properties of the metal ions. As the pH is reduced (acidity increased), the hydroxo-complexes are decomposed, and insoluble metal hydrous oxide flocs redissolve. The result is that the full effect of the metal ion concentration is felt by the microorganism. Thus, the presence of acidity which is in itself inhibitory, causes the full release of metal ions (copper, zinc, iron, lead, etc.) which are also inhibitory, and a synergistic result occurs.

Conversely, alkalinity causes the neutralization of acidity, increases the pH, and tends to precipitate metals out of solution. Thus, alkalinity is antagonistic or decreases the effect of metals. At high pH levels, where hydroxyl ion is inhibitory, acidity is antagonistic to excess alkalinity. Therefore, substances which tend to drive the pH value of the waste toward the neutral point, tend to help the activated sludge process to operate satisfactorily.

Ammonia

Ammonia (NH_3) is a common chemical substance, which is a gas at room temperature. It is extremely soluble in water and its water solution is used as a household cleaning agent. Ammonia forms a series of salts called ammonium salts. Inasmuch as ammonia and ammonium ion occur together in solution and are transformed from one form to another by shifts in the solution pH, the two substances are usually treated as a single substance in most of the wastewater literature.

Ammonia is an important substance in wastewaters and serves as a nutrient material to supply nitrogen needed for microorganism growth. All ammonium salts encountered are completely soluble in wastewater.

Ammonia occurs naturally in most wastewaters as a result of decomposition of nitrogen containing compounds in sanitary wastes. In addition, ammonia is used extensively in chemical manufacture, water softening, agricultural fertilizers, refrigeration, metal cleaning and other diverse applications.

Summary of Inhibitory Properties:

1. At low concentration levels, ammonia serves as an important nutrient in a healthy biological oxidation system.

2. No adverse effects on oxygen consumption are noted at concentrations of up to 100 mg/l of ammonia.

3. At excessively high levels (about 480 mg/l) ammonia exhibits inhibitory effects on the activated sludge process (E-29).

4. At a concentration of 1500 to 3000 mg/l ammonia is inhibitory to anaerobic digestion (E-17, E-20).

Alkali and Alkaline Earth Metals

The common alkali metals, sodium and potassium, and alkaline earths, calcium and magnesium, are widely distributed in nature and are significant components as salts in most water supplies. Consequently, these metals are almost universally present in all wastewater flows, usually as chloride, sulfate or bicarbonate salts.

These metal ions are well tolerated by activated sludge operations, and only at relatively high concentration levels have inhibitory effects been noted. For example, inhibitory effects on the activated sludge process were noted with slug dose concentrations of sodium chloride (common table salt) of 30,000 to 50,000 mg/l (E-5, E-22, E-49), but these inhibitions may be primarily caused by the accompanying high chloride levels (E-91). Upsets of biological treatment processes have been reported in which wastewater contributions containing high chloride levels were indicated as the cause of the upset. Interference with a trickling filter was noted at 20,000 mg/l sodium chloride (E-22). At more moderate concentrations of salt, no interference with these processes were noted.

However, the anaerobic sludge digestion and nitrification processes are more sensitive to these cations, and it appears that important effects are noted when the relative concentrations and absolute concentrations of these metal cations deviate from certain beneficial values. Thus, it has been reported that calcium levels of 100 to 200 mg/l are stimulatory to anaerobic digestion; 2500 to 4500 mg/l are moderately inhibitory to the process; and a concentration level of 8000 mg/l is strongly inhibitory (E-26, E-37, E-120).

Similar relations are noted for magnesium, sodium and potassium. Also, it has been reported that various combinations of alkali and alkaline earth ions and the ammonium ion show either synergistic or antagonistic effects in the operation of the anaerobic sludge digestion process. For nitrification processes a magnesium concentration of 12.5 to 50 mg/l was found to be stimulatory, whereas 50-100 mg/l inhibited the process (E-100).

Arsenic

Arsenic is a metallic element which forms cationic salts of the arsenic and arsenous forms and anion salts of the arsenate and arsenite forms. It is well known for the poisonous properties of its compounds. Arsenic is found at very low concentration levels in most natural waters and is likewise a trace constituent in most foods.

Arsenic can enter sewage treatment systems from a number of commercial operations. A major use of arsenic compounds is agricultural pesticides, where it is used in liquid sprays and dusting powders. Other uses associated with its toxic nature are wood preservatives and medicines. Arsenic compounds also find commercial use in artists' pigments, glass manufacture, and pyrotechnics. Probably the most significant source of arsenic pollution is from agricultural pesticide use.

Summary of Inhibitory Properties:

1. A level of 0.1 mg/l sodium arsenate (arsenic concentration 0.04 mg/l) showed no effect on oxygen uptake, while a level of 1.0 mg/l of this compound depressed oxygen uptake about 50% (E-21).

2. A 0.1 mg/l concentration of arsenic trichloride (about 0.04 mg/l arsenic) likewise reduced oxygen uptake about 50% (E-21).

3. A 4 mg/l concentration of sodium arsenate (about 1.6 mg/l arsenic) resulted in a significant reduction in sludge digestion efficiency (E-5).

Borate (and other boron species)

Boron is a light metal. It forms a series of anionic salts, including borate, metaborate and tetraborate. Boron salts are found widely distributed in natural waters and foods, and therefore are natural constituents of sewage. In addition, boron compounds are constituents of household detergents and medications which also contribute to boron in domestic wastewaters. Boron compounds find application in the manufacture of glass and ceramics, fireproofing, high energy rocket fuels and in the operation of nuclear reactors. Contributions of boron from these sources are probably small.

Summary of Inhibitory Properties:

1. Boron concentrations of 0.005 to 0.05 mg/l are reported to have had no effect on microorganism growth (E-29).

2. Levels of borate from 0.05 to 100 mg/l have been reported to interfere with the activated sludge process in various ways, such as interference with sludge settling and COD removal (E-5, E-9, E-29, E-44).

3. Boron shock loads of 2 mg/l have been reported to have affected anaerobic digestion (E-128).

Cadmium

Cadmium is a transition metal which forms divalent salts. Cadmium salts are somewhat toxic, and are found in domestic water and wastewater sources only at very low levels. Contributions to POTW's come from industrial or commercial sources, with the principal contributions of cadmium coming from metal plating processes. Cadmium also finds significant use in pigment manufacture, photographic applications, dyeing and calico printing.

Summary of Inhibitory Properties:

1. Cadmium has no adverse effects on the activated sludge process up to a concentration level of about 1 mg/l (E-21).

2. In the range of 10 to 100 mg/l, cadmium shows various deleterious effects, such as decrease in BOD removal efficiency and reduction in oxygen uptake (E-21, E-29).

3. An investigator reports that 0.02 mg/l should be considered a threshold concentration for cadmium in digestors (E-104).

Synergistic and Antagonistic Effects:

Synergistic effects have been reported on cadmium and zinc, as well as cadmium and manganese. Other heavy metals may also show synergistic effects with cadmium. There is no doubt that acidity would show a synergistic effect with cadmium.

Sulfide and high pH (8 and above) are strongly antagonistic with cadmium, since they precipitate the insoluble sulfide and hydroxide compounds.

Chromium

Chromium is a transition metal which forms two important series of salts, the trivalent chromic cation and the hexavalent chromate anion. Chromium is present as a trace constituent in domestic sewage, but the levels encountered are not significant relative to POTW operation.

Chromium is contributed to wastewater from numerous industrial and other commercial operations. Especially significant sources are the electroplating and electrofinishing industries. Another significant source is the use of soluble chromates as corrosion inhibitors in cooling towers and insoluble chromates in corrosion resistant coatings. Other sources of commercial discharge of chromium salts include leather tanning, photographic processing, and textile dyeing. Unless stated otherwise, the inhibitory properties outlined below are for hexavalent chromium.

Summary of Inhibitory Properties:

1. Effect of Chromium on the Activated Sludge Process:

a. At a concentration level of 0.005 to 0.05 mg/l, chromium has a stimulatory effect on microorganism growth (E-5).

b. Interference with biological processes is reported at the 1 mg/l concentration level (E-5).

c. Another investigator identifies 10 mg/l as the threshold level for deleterious effects (E-29, E-78).

d. In the concentration range of 1 to 50 mg/l, the published literature is quite confusing and contradictory, ranging from serious interference to insignificant effects (E-29, E-118).

e. In the range of 50 to 500 mg/1, the published results describe various deleterious effects. These include synergistic effects of chromium with acidity, iron and copper (E-5, E-29, E-21, E-118).

f. Slug doses up to 500 mg/1 of chromium have been reported to result in relatively minor disturbances to the activated sludge process (E-29, E-12, E-36).

g. Up to 50 mg/1 of trivalent chromium was reported to have an adverse effect on activated sludge processes (E-88).

2. Sludge Digestion

a. Chromium levels of up to 500 mg/1 in the plant influent do not affect digestion of the resultant sludge. This result may be due to precipitation of the insoluble chromic hydrous oxide (E-118).

b. The addition of up to 50 mg/1 of chromium directly to a sludge digester had a serious effect on digestion (E-78), and the addition of 500 mg/1 to the digester stopped the process completely (E-118).

c. The effect of trivalent chromium on digestor operation has been reported to be dependent on the digestion period. 500 mg/1 trivalent chromium is tolerated in digestors with 20 day digestion periods, 100 mg/1 with 17 days of digestion, and 50 mg/1 with 14 days (E-88).

3. Nitrification

a. It has been reported that 0.25 mg/1 of chromium will inhibit nitrification to some extent (E-119).

b. From 2 to 5 mg/1 of chromium completely inhibits the nitrification process (E-29, E-117, E-13).

4. Sludge Settling

a. Concentrations ranging from 7 to 500 mg/1 of chromium interferes with sludge settling (E-29).

Copper

Copper is a transition metal which forms salts and other compounds in two valence forms. Monovalent copper, copper (I), forms a series of chemical salts called "cuprous", while divalent copper, copper (II), forms a series of "cupric" compounds. The cuprous compounds are all relatively insoluble and uncommon, and are not significant in water pollution or water treatment chemistry. Therefore, in this document, attention has been focused on cupric compounds only, and references to "copper" below signify the cupric form only.

The majority of common copper compounds are insoluble, and therefore do not pose a problem to sewage systems in that form. However, copper nitrate, sulfate, chloride salts, and a number of copper complexes are soluble and these may pose problems when discharged to sewage treatment plants.

Copper compounds occur naturally in surface and ground waters, usually at relatively low concentration levels, and are natural constituents of domestic drinking water supplies. Copper also enters domestic sewage flows as a result of routine household activities, such as washing and preparing of foods, cleaning of copper utensils, and use of garbage disposal units to macerate waste foods. In addition, copper salts discharge to sanitary sewers as a result of corrosion of copper and brass plumbing fixtures and pipes. Also, corrosion of copper roofing and surface run-off leads to additional discharge of copper to combined sewage systems.

Finally, copper compounds are discharged from a number of industrial operations such as metal cleaning and electroplating operations. Engraving, jewelry, electrical manufacturing, chemical industrial processes, and algicide and insecticide uses all add copper to industrial wastewaters.

Copper is an essential nutritional food element for man and lower organisms, and is no doubt essential to the proper operation of biological waste treatment systems at some undetermined trace level. At extremely high concentration levels (about 1000 mg/l and above) essentially all forms of living species are destroyed and essentially sterile water results (E-121).

The sewage plant operator is concerned with intermediate concentration levels, at which copper-bearing wastewater may be processed through the system without causing significant plant upset. Above this safe copper concentration, he may be interested in the various inhibitory effects which may result. It is expected that the various biological treatment systems may respond differently to the same level of copper in wastewater.

Summary of Inhibitory Properties:

1. Synergism of copper with the following substances has been identified: cyanide, acidity (low pH) and other heavy metals.

2. Antagonism of copper with the following substances has been identified: sulfide, high pH, and certain chelating agents such as EDTA (E-100).

3. Effect of Copper and Copper Complexes on Activated Sludge Plants

a. One mg/l of copper has been reported to be the threshold limit for continuous feed of copper to the activated sludge process (E-5, E-2, E-109, E-24, E-78).

b. A pilot plant study showed an effect on the process at 1.2 mg/l, while at 10 mg/l a small reduction of plant efficiency of about 4% or less was reported (E-4, E-24, E-78, E-118).

c. The combination of 3.6 mg/l of copper with 8.6 mg/l of cyanide caused a serious upset of the process (E-16).

d. Another reference cites 0.1 mg/l as the recommended upper limit of copper ion in sewage feed (E-2).

e. For slug doses, it has been reported that doses above 50 mg/l for 4 hours show a severe effect (E-21); a 64 mg/l dose for 4 hours showed a slight effect (E-118); a 75 mg/l dose for 4 hours "affected" the system (E-29); and 100 to 400 mg/l showed a severe effect in which plant efficiency dropped to about 50% for 48 hours as a result of the slug dose (E-118, E-2).

f. Ten mg/l of copper in the presence of cyanide caused a severe effect (E-29), while 25 mg/l of copper in the presence of cyanide caused a very severe effect for 24 hours (E-118).

g. It has been reported that there is an approximate one-to-one relationship between copper concentration and effluent COD. A one mg/l increase in copper will result in a one mg/l increase in effluent COD (E-60).

Note that the severity of effects reported for slug doses of copper does not correspond quite proportionally with the concentrations of these doses. Nevertheless, it may be concluded that slug doses of copper from 50 to 400 mg/l result in serious upset conditions with the activated sludge process.

4. Effect of Copper on Sludge Digestion

a. Data reported on the effect of continuous dosages of from 0.1 to 10 mg/l of copper in influent wastewater on sludge digestor operation vary widely.

b. Two investigators recommend 1.0 mg/l as the maximum concentration of copper in influent wastewater to avoid digestor operating difficulty (E-5, E-15).

c. For direct feed to a combined sludge digestor, a 5 mg/l copper dosage is recommended as an upper limit. For primary sludge digestion, 10 mg/l copper is the recommended upper limit (E-78).

d. Various copper concentrations in digestors greater than 10 mg/l have been found to be inhibitory (E-1, E-2, E-118).

These data may be summarized by stating that over the range of copper concentration from 0.1 to 10 mg/l, there are reports of digestor problems attributed to the presence of copper, and other reports of digestor tolerance to these same levels. These discrepancies are no doubt explicable in terms of differences in operating conditions, and antagonistic or synergistic effects.

5. Nitrification - One investigator reports that 0.005 to 0.03 mg/l of copper is stimulatory to nitrifying bacteria, concentrations above 0.05 mg/l copper were found to be inhibitory (E-100), and 0.5 mg/l of copper as copper sulfate has been reported as inhibitory to nitrification (E-2).

Cyanide

The cyanide ion (CN^-) is a pollutant parameter of significant interest in POTW influent and effluent, as well as in rivers, streams and lakes. Its poisonous character is universally known, and accounts for the interest in this pollutant. The poisonous nature of cyanide is actually associated more with hydrogen cyanide, which generally is more prevalent below pH 7, than with the free cyanide ion. Therefore, cyanide toxicity is directly tied to the pH of the wastewater. Another interesting aspect of its poisonous character is that its toxicity is principally applicable to higher life forms. Microorganisms present in sewage treatment plants can adapt to the presence of cyanide, and metabolize and destroy it even at fairly high concentration levels.

An important property of the cyanide ion is that it is a powerful complexing agent and can bind with transition and other heavy metal ions to form metal cyanide complexes. These complexes exhibit neither the properties of the metal ion nor the cyanide ion, and thus are actually different chemical substances.

Cyanide is not a normal constituent of domestic sewage, and its presence in wastewaters is almost exclusively a result of manufacturing processes and commercial operations. Principal sources of cyanide in wastewater are the electroplating, coke, petroleum gas, steel, plastics, and chemical industries. The electroplating industry is particularly noteworthy because it combines cyanide wastes with transition and heavy metal ion wastes.

Summary of Inhibitory Properties:

1. Wastewaters containing 0.01 to 0.05 mg/l of cyanide have no deleterious effect on an activated sludge plant (E-118). At levels of from 0.3 to 3 mg/l of cyanide, some adverse effects are reported (E-21).

2. Recommended maximum limits of 0.1 to 2 mg/l of cyanide have been reported in the literature (E-5, E-118).

3. 5 mg/l of cyanide in raw wastewater has been found to interfere with activated sludge processes (E-15).

4. A slug dose of 40 mg/l of cyanide upset an activated sludge plant for two days (E-29). On the other hand, after acclimation, 60 mg/l was tolerated in an activated sludge plant (E-21) and 200 mg/l was tolerated in a trickling filter plant (E-29).

5. It has been reported that the toxicity of copper and nickel are enhanced by the presence of cyanide (E-16, E-118).

6. It was reported that cyanide levels of 4 to 100 mg/l upset the sludge digestion process from four days to complete retardation (E-5).

7. Trickling filter operations have been impaired by 30 mg/l of cyanide (E-7), but 10 mg/l were destroyed by trickling filter operations.

8. The nitrification process was reported to be inhibited by about 75% by 0.65 mg/l of sodium cyanide (0.34 mg/l of cyanide) (E-129). Other reports indicate that 2 to 72 mg/l of cyanide as HCN interfered with nitrification, the upper value completely inhibiting the process (E-5).

9. The cyanide ion shows a remarkable range of behavior with biological processes, from interference at low concentrations with non-acclimated systems, to tolerance at high levels in acclimated systems.

Iron

Iron is a transition metal forming two groups of salts, the divalent ferrous salt series and the trivalent ferric salt series. Both the ferrous ion and the ferric ion are precipitated from solution at neutral pH values as hydroxides.

Iron salts are natural constituents of both domestic and commercial wastewaters. While the levels in domestic sewage are always low, the levels in certain industrial or commercial wastes may be excessive. Major industrial sources include metal pickling and cleaning processes, chemical manufacturing, electric utilities, etc.

Summary of Inhibitory Properties:

1. Iron is a necessary element for microbiological growth and its absence causes a reduction in metabolic activity (E-39, E-112).

2. The activated sludge process appears to be rather insensitive to iron concentration except for very high concentration levels. It is reported that 100 mg/l causes little adverse effect, but 1000 mg/l stops oxygen uptake (E-21).

3. The sludge digestion process is more sensitive to soluble iron concentration. It is reported that 5 mg/l is a maximum level, as higher iron levels cause interference with the process, due to hydrolysis of the iron and release of acidity (A-1). As has been previously emphasized, the sludge digestion process is very sensitive to pH values outside the optimum range of 6.5 to 7.5. Therefore, the inhibitory effect

of iron is no doubt due to the acidity released (E-5, E-118).

4. A technique to control metal interference with sludge digestion is to add iron sulfide directly to the digester. Iron sulfide, although very insoluble, is more soluble than most other metal sulfides. When a metal, e.g., copper, enters the digestor, it reacts with the iron sulfide to precipitate the copper sulfide, and thus removes the copper from solution. The less "toxic" iron is solubilized as a result. If the pH is stabilized in the optimum range, the iron is largely precipitated out as the hydroxide, and the digester is protected from the effect of the copper. The selection of iron sulfide for this use is a result of its inherent low "toxicity" to microorganisms.

Synergistic and Antagonistic Effects:

Synergistic effects occur between pairs of transition metal ions present in a wastewater. A specific effect of iron synergism with chromium has been reported and synergism with other metals may also occur (E-29).

Antagonistic effects may be anticipated with sulfide ion and hydroxyl ion (high pH), due to precipitation of the sulfides and hydroxides of iron. An antagonistic effect should be expected with cyanide, since the ferrocyanide complex is very stable and no doubt non-inhibitory to biological processes.

Lead

Lead is found in natural waters at trace levels as the divalent ion. It occurs in domestic sewage as a result of its presence in the water supply and also as a result of corrosion of lead plumbing. It is present in industrial wastewaters from storage battery manufacture, tetraethyl lead production, and pigment, paint and cement industries. It also is contributed to wastewater flow as a result of manufacture and use of lead-containing pesticides.

Summary of Inhibitory Properties:

1. At concentration levels of 0.005 to 0.05 mg/l, lead has no effect on the activated sludge process. A moderate "toxicity" of lead to microorganisms has been reported above 0.1 mg/l and also above 1 mg/l (E-5).

2. In apparently contradictory results, one paper states that a significant effect on oxygen uptake is noted

in the presence of lead from 10 to 100 mg/l (E-29), while a second paper states that no significant change in oxygen consumption is noted at up to 50 mg/l (E-21).

3. Lead concentrations of up to 0.05 mg/l have been reported to have no effect on the nitrifying bacteria nitrosonomas (E-100).

Manganese

Manganese is found in domestic sewage in trace amounts. The significant aqueous form is the divalent ion. Manganese is contributed in the wastewaters from storage battery manufacture, paint manufacture, chemical manufacture, etc.

Summary of Inhibitory Properties:

1. It has been reported that a concentration of 7 mg/l of manganese has no adverse effect on the activated sludge process. However, two reports indicate that at 10 mg/l of manganese, a severe adverse reaction occurred with the activated sludge process, and a severe inhibition of oxygen uptake was experienced. Oxygen uptake was completely inhibited at 50 mg/l of manganese (E-21).

2. Manganese salts in the concentration range of 12.5 to 50 mg/l have the unusual property of stimulating the growth of the microorganism nitrosonomas (E-29).

Synergistic and Antagonistic Effects:

Synergistic effects of manganese with zinc and cadmium have been reported (E-29). It is probable that similar synergistic effects may occur with other transition and heavy metals, and with acidity.

Although no data have been found on antagonistic effects with manganese, it may be presumed that hydroxide and sulfide, which can precipitate manganese, will act in this manner.

Mercury

Mercury forms two series of salts, the monovalent mercurous salts and the divalent mercuric salts. Most mercury salts (of either valence form) are considered to be insoluble or sparingly soluble. However, because of the severe toxicity of mercury to man, fish, wildlife, and lower organisms, even the slight solubility poses a substantial threat.

Mercury is found in typical domestic wastewaters at extremely low levels. Commercial contributions occur principally from the chlor-alkali industry (chlorine-caustic soda manufacture). Other sources include chemical, drug, herbicide, fungicide, and paper products from these industries.

Summary of Inhibitory Properties:

1. At a concentration level of 0.1 mg/l of mercury, one paper reports no effect on the activated sludge process (E-21); another paper reports a 10% reduction in oxygen uptake (E-28).

2. A threshold level for adverse effects of mercury on the activated sludge process is reported at about 2.5 mg/l (E-21).

3. An investigator reports that at less than 2.5 mg/l, mercury has little effect on aerobic processes, but at above 5.0 mg/l,aerobic processes are definitely inhibited (E-70).

4. In the concentration range of 1 to 200 mg/l there are numerous reports of different degrees of inhibitory effects on the activated sludge process (E-122, E-29, E-21).

5. A study of mercury behavior in the sludge digestion process indicated that 43 mg/l of mercury in the digester had no adverse effect, and that 1365 mg/l had an adverse effect (E-18).

Nickel

Nickel is a transition metal which forms a series of divalent (nickelous) salts and trivalent (nickelic) salts. Only the divalent salts are of interest in wastewater management. Nickel is present as a trace constituent in domestic wastewaters. Nickel is contributed from some commercial sources at much higher levels, which could disrupt the operation of a POTW if no control were used.

The major source of nickel contribution to wastewaters is from electroplating and related metal finishing processes. Other minor sources of nickel in wastewater arise from corrosion of alloys, dyeing, and printing operations.

Summary of Inhibitory Properties:

1. Activated Sludge Process

a. There appears to be no significant adverse effect from nickel concentrations of less than one mg/l (E-118).

b. A threshold effect of nickel on the activated sludge process is reported between one and 2.5 mg/l (E-118).

c. Various adverse effects on the activated sludge process are reported for nickel influent concentrations of 2.5 to 200 mg/l (E-19, E-21, E-25). These include reduced oxygen uptake between 10 to 50 mg/l of nickel and interference with solids settling between 2.5 and 10 mg/l of nickel (E-14).

2. Sludge Digestion - The data available on sludge digestion in the presence of nickel show little or no effect of nickel (from 10 to 500 mg/l) on the sludge digestion process (E-1, E-3, E-4, E-19, E-21, E-29, E-118). In view of the sensitivity of microorganisms to nickel ions, it is clear that the reason no effect was noted (except in one instance (A-1), with up to 500 mg/l of nickel, is because sulfide and perhaps hydroxide have precipitated the nickel out of solution, rendering it harmless. In the absence of adequate sulfide (or sulfate) in the digester one would expect lower levels of nickel to interfere with the process.

3. Nitrification - It is reported that a level of one-half to three mg/l of nickel has an adverse effect, and 10 mg/l has a very adverse effect on the nitrification process (E-25, E-118).

Silver

Silver is a transition metal which forms a series of monovalent salts. It has few soluble salts. Silver is not normally a significant constituent of domestic wastewaters. Because of its relatively high cost, commercial contributors usually make an effort to recover as much silver as is economically practical.

The principal source of silver in wastewaters is the photo processing industry. Silver salts are removed from photographic film with sodium thiosulfate (hypo), and the films are rinsed free of the hypo. In large photoprocessing installations, the silver is recovered from the hypo. Residual traces in rinse water are not economical to recover, and these residuals result in contributions to the waste load.

Silver ion is extremely toxic to microorganisms, being one of the most reliable disinfectants known. Therefore, it would be anticipated that silver discharges to a POTW could cause interferences with its operation. However, in the case of contributions from the photoprocessing industry, the sterilizing effect of silver is generally not encountered. The reason for this anomaly is that virtually all of the silver released from a photoprocessing plant is in the form of the thiosulfate complex. This complex does not display any of the "toxic" properties of silver ion.

Summary of Inhibitory Properties:

1. Free silver ion at the 5 mg/l level causes an 84% inhibition of the activated sludge process (E-8, E-9). At the 25 mg/l level, inhibition is complete (E-21).

2. In contrast, silver present as the thiosulfate complex, at levels of from 2 mg/l to greater than 250 mg/l of silver had no effect (E-8, E-9).

Sulfate

The sulfate radical is a common constituent of natural water supplies and, as a result, is also a common constituent of domestic and commercial wastewater streams. Numerous industries release sulfates; for example, metal cleaning or "pickling" is carried out with sulfuric acid, which may be neutralized and contributed to a municipal sewer. Similarly, air pollution scrubbers collect abundant quantities of sulfates and sulfites which may be released to the sewers.

Summary of Inhibitory Properties:

1. No data have been found on inhibitory effects of sulfate on the activated sludge process but presumably, adverse effects would occur at some elevated concentrations.

2. Inhibitory effects have been noted in sludge digestion. At greater than 500 mg/l, an adverse effect of sulfate in sludge digesters is reported (E-11, E-17). At a level of 2400 mg/l of sulfate, it is reported that the gas generation was reduced by less than 12% from that without high sulfate level. At a sulfate level greater than 2400 mg/l, there is a report of complete cessation of gas production (E-19).

Sulfide

The sulfide ion is a common constituent of domestic wastewater, especially when anaerobic conditions occur. Sulfides may be discharged in wastes from petroleum refining, the leather tanning industry, and chemical manufacturing industries.

Summary of Inhibitory Properties:

1. Excessive levels of sulfide would interfere with the activated sludge process by depleting the dissolved oxygen transferred in the aeration process. One investigator reports that 25 to 50 mg/l of sulfide, is tolerable for about one week (E-29).

2. Sulfide is beneficial to the anaerobic digestion process at low concentrations because of its ability to precipitate transition and heavy metals out of solution. At higher concentrations, and subject to conditions in the digester, sulfide becomes inhibitory.

3. Reports of tolerance to sulfide in the sludge digestion process include the following reports: 50 to 100 mg/l of sulfide can be tolerated (E-120); 200 mg/l causes less than 12% loss in gas generation (E-19); and up to 200 mg/l of sulfide can be tolerated (E-120).

4. Sulfide concentrations of 150 to 200 mg/l in the digestor feed reduced gas production considerably (E-35, E-19).

5. Reports of inhibitory effects include the following conclusions: Greater than 50 mg/l of sulfide reduces gas production considerably; 100 mg/l of sulfide causes from a 33% to 50% loss in gas generation; no methane forms with more than 165 mg/l of sulfide; 200 mg/l of sulfide causes an 80% loss of gas generation; greater than 200 mg/l of sulfide is quite toxic, causing complete cessation of gas generation; and 400 mg/l of sulfide causes 95% loss of gas generation (E-19).

It is clear that the effect of a given level of sulfide ion may be quite variable, depending on specific process conditions. The reported contradictory effects of sulfide on anaerobic digestion, points to the dependence of inhibition or tolerance on other factors.

Zinc

Zinc is a transition metal which forms a series of divalent salts. It has amphoteric behavior; i.e., it forms zinc cations and zincate anions. Zinc has a rather widespread occurrence, and is a normal constituent of domestic wastewaters. Zinc is contributed to sewage flow from a number of industries, including electroplating, dye and pigment manufacture, rubber processing, and electrical generation.

Summary of Inhibitory Properties:

1. Activated Sludge Process

a. A number of reports cite tolerance of the activated sludge process to zinc, up to concentration levels of 10 mg/l (E-4, E-6, E-21).

b. There is a report of an adverse effect in the 0.08 to 0.5 mg/l range and a report that the threshold level is between 5 and 10 mg/l (E-29, E-33).

c. Reports of inhibitory effects are given over the range of 20 to 160 mg/l (E-118, E-29, E-6, E-5, E-67).

d. Synergistic effects are noted between one mg/l of zinc with 10 mg/l of cadmium, between 10 mg/l of zinc and 100 mg/l of manganese, and between 10 mg/l of zinc and 10 mg/l of cadmium.

2. Sludge Digestion

a. Two references cite no adverse effects of zinc with the sludge digestion process for 10 mg/l and 10 to 20 mg/l of zinc, respectively (E-3, E-6).

b. Two references cite adverse effects of zinc on the sludge digestion process at 20 mg/l and 1000 mg/l respectively (E-118, E-5). Other investigators indicate 5 mg/l zinc as the upper limit to prevent decreases in digestor gas production (E-7, A-1), and 10 mg/l as the highest continuous dosage that will allow satisfactory digestion (E-78).

3. Solids Settling

a. Adverse effects on solids settling have been reported for 7.5 and 15 mg/l slug doses of zinc solution over a half hour period (E-29).

4. Nitrification - Inhibition of nitrifying bacteria by 0.08 to 0.5 mg/l of zinc has been reported (E-100).

Organic Substances

Organic chemicals may be characterized as those compounds made up of carbon in combination with hydrogen, oxygen, nitrogen, sulfur or phosphorus. The following list is representative of some of the categories of organic compounds with biological and/or commercial importance.

- Petroleum products
- Perfumes and flavors
- Antibiotics and vitamins
- Insecticides and fertilizers
- Plastics and synthetics
- Dyes and pigments
- Sugars
- Paint and coatings
- Explosives and propellants

Wastewaters reaching a POTW may contain any number of organic substances.

Although most organic compounds appear to be compatible with aerobic biological treatment systems, some have been known to cause treatment plant upsets.

It appears to be generally true that anaerobic digestion is the biological treatment process which is most susceptible to upset by inhibitory substances, especially chlorinated hydrocarbons (E-109). Nitrification is also sensitive to organics, although acclimation is possible. Autotrophic bacteria which are involved in nitrification are more readily inhibited than are the heterotrophic bacteria which are involved in the oxidation of carbon compounds. Organic sulfur compounds, especially those with sulfur-carbon-nitrogen linkage are inhibitors of nitrification (E-109).

The significant organic constituents which have been identified as having inhibitory effects are discussed below, and are summarized in Table E-2. In addition to inhibitory effects, there may be other compelling reasons for limiting specific parameters, such as those organic constituents which are proven carcinogens.

Alcohols

An alcohol is a hydrocarbon in which one of the hydrogens is replaced by a hydroxy (-OH) group. The lower molecular weight alcohols are relatively polar substances and are completely miscible with water. With increasing size of the hydrocarbon group the alcohols become increasingly insoluble in water. Polyhydroxy alcohols contain more than one hydroxy group per molecule. One of these, ethylene glycol, is used

TABLE E-2

THRESHOLD CONCENTRATIONS OF ORGANIC POLLUTANTS THAT ARE INHIBITORY TO BIOLOGICAL TREATMENT PROCESSES

POLLUTANT	CONCENTRATION (mg/1) ACTIVATED SLUDGE PROCESSES	ANAEROBIC DIGESTION PROCESSES	NITRIFICATION PROCESSES	REFERENCES
Alcohols				
Allyl		100	19.5	E-11, E-129
Crotonyl		500		E-11
Heptyl		500		E-11
Hexyl		1000		E-11
Octyl		200		E-11
Propargyl		500		E-11
Phenols				
Phenol	200		4-10	E-23, E-102
Creosol			4-16	E-102, E-129
2-4 Dinitrophenol			150	E-129
Chlorinated Hydrocarbons				
Chloroform		10-16		E-11, E-110
Carbon Tetrachloride		10-20		E-51, E-103, E-109, E-107
Methylene Chloride		100-500		E-51, E-107
1-2 Dichloroethane		1		E-109
Dichlorophen*		1		E-109
Hexachlorocyclohexane		48		E-109
Pentachlorophenol*		0.4		E-109
Tetrachloroethylene		20		E-109
1,1,1,-Trichloroethane		1		E-109
Trichloroethylene		20		E-109
Trichlorofluoromethane*		0.7		E-109
Trichlorotriflouroethane (Freon)		5		E-109
Allyl Chloride			180	E-129
Dichlorophen			50	E-129
Organic Nitrogen Compounds				
Acrylonitrile		5		E-109

TABLE E-2 (Continued)

POLLUTANT	CONCENTRATION (mg/1) ACTIVATED SLUDGE PROCESSES	ANAEROBIC DIGFSTION PROCESSES	NITRIFICATION PROCESSES	REFERENCES
Organic Nitrogen Compounds (Continued)				
Thiourea			0.075	E-109, E-129
Thioacetamid			0.14	E-109, E-129
Analine			0.65	E-129
Trinitrotoluene (TNT)	20-25			E-33
EDTA	25		300	E-93, E-129
Pyridine			100	E-102
Surfactants				
Nacconol	200			E-63
Ceepryn	100			E-63
Miscellaneous Organic Compounds				
Benzidine	500	5		E-10
Thiosemicarbazide			0.18	E-129
Methyl isothiocyanate			0.8	E-129
Allyl isothiocyanate			1.9	E-129
Dithio-oxamide			1.1	E-129
Potassium thiocyanate			300	E-129
Sodium methyl dithiocarbamate			0.9	E-129
Sodium dimethyl dithiocarbamate			13.6	E-129
Dimethyl ammonium dimethyl dithiocarbamate			19.3	E-129
Sodium cyclopentamethylene dithiocarbamate			23	E-129
Piperidinium cyclopentamethylene dithiocarbamate			57	E-129
Methyl thiuronium sulphate			6.5	E-129
Benzyl thiuronium chloride			49	E-129

TABLE E-2 (Continued)

POLLUTANT	ACTIVATED SLUDGE PROCESSES	ANAEROBIC DIGESTION PROCESSES	NITRIFICATION PROCESSES	REFERENCES
	CONCENTRATION (mg/l)			
Miscellaneous Organic Compounds (Contd.)				
Tetramethyl thiuram momosulphide			50	E-129
Tetramethyl thiuram disulphide			30	E-129
Diallyl Ether			100	E-129
Dimethyl-paranitrosoaniline			7.7	E-129
Guanidine carbonate			19	E-129
Skatole			16.5	
			7.0	E-129
Strychnine hydrochloride			175	E-129
2 chloro-6 trichloro-methyl-pyridine			100	E-129
Ethyl urethane			250	E-129
Hydrazine			58	E-129
Methylene blue			100	E-129
Carbon disulphide			35	E-129
Acetone			840	E-129
8-hydroxyquinoline			73	E-129
Streptomycin			400	E-129

Note: Concentrations shown represent influent to the unit process. Where indicated with a *, the concentration represents total plant influent.

extensively as an antifreeze. Alcohols may be found in the effluents from the pharmaceuticals, alcoholic beverages, anti-freeze chemicals and plastics manufacturing industries. One investigator reports that 19.5 mg/l of alkyl alcohol inhibits nitrification by 75% (E-129).

Effect of Some Alcohols on Anaerobic Digestion

Alcohol	Use	Water Solubility	Inhibitory Concentration (mg/l)
Allyl ($CH_2=CH-CH_2OH$)	Plastics	Miscible	100
Propargyl ($CH=C-CH_2OH$)		Miscible	50
Crotonyl ($CH_3-CH=CH-CH_2OH$)		Partly Soluble	500
Hexyl ($C_6H_{13}OH$)	Antiseptic	Slight	1000
Heptyl ($C_7H_{15}OH$)		Slight	500
Octyl ($C_8H_{17}OH$)	Perfume	Insoluble	200

Phenols

Phenols are aromatic hydrocarbons with a hydroxy (-OH) group substituted for a hydrogen in the ring. Cresols are phenols with a methyl group substituted for a second hydrogen in the benezene ring. Domestic wastewaters do not generally contain significant amounts of phenols. Phenols can cause significant problems if present in domestic water supplies since the chlorophenols that may be produced during chlorination can be odorous.

Phenols are basic organic chemicals used in many industrial syntheses, including plastics production, dyes, and pharmaceuticals. Phenolic wastewater is also produced as a by-product of petroleum refining.

Summary of Inhibitory Properties:

There is an extremely diverse reaction to phenolic wastes in the activated sludge process depending upon whether the sludge has been acclimated to phenol. Relatively small amounts of phenol can be inhibitory to unacclimated sludge. However, with acclimation, and use of the complete mixing mode of operation, high concentrations of phenol can be tolerated. The following results taken from the literature substantiate this conclusion (E-23).

1. Phenol slug doses of 200 mg/l can deactivate aerobic treatment plants by killing the biomass (E-23).

2. One investigator reports a progressive inhibition of nitrification between 4 and 10 mg/l of phenol or creosol. 5.6 mg/l of phenol has been found to inhibit nitrification by 78% (E-129). Cresol at concentrations of 4-5 mg/l inhibits nitrification(E-102). 12.6 mg/l of o-cresol, 11.4 mg/l of m-cresol and 16.5 mg/l of p-cresol were found to inhibit nitrification by 75% (E-129).

3. 150 mg/l of 2-4 dinitrol phenol also decreased nitrification by 75% (E-129).

4. A particular bacteria found in the activated sludge biomass (bacillus cerus) is capable of metabolizing phenol. Concentrations of up to 1000 mg/l of phenol are not harmful to this species (E-32).

Chlorinated Hydrocarbons

Hydrocarbons in which one or more hydrogen atom is replaced by a chlorine atom can be classified as chlorinated hydrocarbons. These materials do not occur in nature but can be found in domestic water supplies as a result of chlorine disinfection and the consequent chlorination of trace hydrocarbons. Chlorinated hydrocarbons are known for their persistance in the environment and are considered especially dangerous because of their ability to be accummulated in the tissues of higher life forms. As a result, many chlorinated hydrocarbons, particularly pesticides, have been banned from environmental use, or their use has been curtailed.

Chlorinated hydrocarbons are employed in a broad range of industrial applications including use as solvents and degreasing agents, agricultural chemicals, disinfectants, dry cleaning agents, soaps and shampoos, wood preservatives, propellants and refrigerants, as well as in chemical manufacturing. The inhibitory properties of several important chlorinated hydrocarbons are detailed below.

Chloroform

Chloroform ($CHCl_3$) is a low boiling point liquid which is only slightly soluble in water. It is used as a solvent for fats, oils, rubber, alkaloids, waxes, resins, as a cleansing agent, in fire extinguishers, and in the rubber manufacturing industry.

Summary of Inhibitory Properties:

1. Continuous doses of chloroform at 16 mg/l or more in the raw sludge feed caused inhibition of anaerobic digestion. Continuous doses at concentrations of 10 and 11 mg/l produced a noticeable drop in gas yield (E-110, E-11).

2. At 1.5 mg/l of chloroform there is no inhibition of sludge digestion, while at 14.9 mg/l inhibition is complete (E-51).

3. One investigator reported slight reduction in digester gas production caused by chloroform at a concentration of 0.1 mg/l. Also included in this report is a reference to an investigation that reported a 50% gas reduction due to 0.96 mg/l of chloroform (E-107).

4. The effect of shock dosing with chloroform was determined in laboratory digesters. The table shows the average percentage inhibition of gas production for each shock dose in the raw sludge (E-110):

Shock Dose of $CHCl_3$ in Raw Sludge Feed (mg/l)	Average % Inhibition
1	3.1
5	10
10	16.9
16	42.3
20	54.3

Carbon Tetrachloride

Carbon tetrachloride (CCl_4) is a colorless nonflammable liquid which is insoluble in water and has a characteristic odor. It is very toxic to humans. It is a general purpose solvent with broad industrial applications. Carbon tetrachloride has been used as a fire extinguisher, a drying agent, a chemical intermediate, and as an exterminating agent.

Summary of Inhibitory Properties:

1. Carbon tetrachloride at levels of 10 mg/l in sludge has been found to be toxic to anaerobic digestion (E-109).

2. Carbon tetrachloride is reported to inhibit digestion as follows (E-51):

Concentration Level (mg/l)	Percent Inhibition
0.8	0
7.9	40
19.7	90
159.4	100

3. 50% reduction in methane production occurred at 2.2 mg/l (E-107).

4. Another investigator showed that 100% inhibition of gas production during anaerobic digestion required a carbon tetrachloride dosage of 16 mg/l (E-103).

Methylene Chloride

Methylene chloride (CH_2Cl_2) is a colorless, nonflammable, liquid which is slightly water soluble. It is used as a solvent for cellulose acetate, as a degreasing agent, cleaning fluid and anesthetic.

Summary of Inhibitory Properties:

1. Methane production in anaerobic digestion was reduced by 50% in the presence of 100 mg/l of methylene chloride (E-107).

2. Methylene chloride showed the following reduction in gas production during anaerobic digestion for each dosage in the raw sludge (E-51):

Concentration (mg/l)	Percent Inhibition
1.3	0
3.3	40
9.9	60
132.6	80
530.4	100

Chlorobenzenes

Chlorobenzenes are used as solvents, chemical intermediates, for moth control and as deodorants.

Summary of Inhibitory Properties:

1. The following table presents data on the inhibitory effect of chlorobenzenes in batch digestion tests (E-107):

Material	Time from start of Test (days)	Concentration (% wt/wt dry sludge solids) in digester contents % Reduction in Gas Production			
		20	35	50	80
Chlorobenzene	2	1.3	1.7	2.1	3.4
	4	1.0	1.4	1.9	3.4
	6	0.94	1.3	1.7	3.0
Orthodichlorobenzene	2	1.1	1.6	2.4	5.4
	4	0.88	1.4	2.0	4.7
	6	0.73	1.2	1.6	3.8
Paradichlorobenzene	2	2.1	2.6	3.0	8
	4	1.8	2.4	3.1	7-8
	6	1.4	2.1	2.7	5.3
Certi-chlor*	2	0.7	1.6	2.5	4.9
	4	0.62	1.3	2.1	4.9
	6	0.54	1.1	2.0	4.3

* A proprietary material similar to ortho-dichlorobenzene and consisting largely of that material.

Miscellaneous Chlorinated Hydrocarbons

1. The following table was developed by an investigator to describe the concentrations of various chlorinated hydrocarbons that have exhibited inhibitory effects on anaerobic treatment processes (E-109).

Toxicity of Some Chlorinated Hydrocarbons to Anaerobic Digestion

Chlorinated Hydrocarbon	Inhibitory Concentrations (mg/l) In Sewage	Inhibitory Concentrations (mg/l) In Sludge
Carbon tetrachloride		10
1,2 Dichloroethane		1
Dichlorophen	1	
Hexachlorocyclohexane		48
Methylene Chloride	1	
Pentachlorophenol	0.4	
Tetrachloroethylene		20
1,1,1-Trichloroethane		1
Trichloroethylene		20
Trichlorofluoromethane	0.7	
Trichlorotrifluoroethane		5

2. A slight reduction in digester gas production was observed as a result of a concentration of 0.1 mg/l of 1,1,1-trichloroethane (E-107).

3. A 75% reduction in nitrification was reported in the presence of 180 mg/l of allyl chloride (E-129).

Agricultural Chemicals

Insecticides, pesticides, and herbicides are manufactured from chlorinated hydrocarbons and from organo-phosphorus compounds. Some of these materials are damaging to sewage treatment processes and to fish and wildlife in very small concentrations (DDT, aldrin, dieldrin). Whereas most other chlorinated hydrocarbons enter the wastewater stream as a result of industrial manufacturing processes, agricultural chemicals usually enter wastewater and natural streams by means of runoff.

Summary of Inhibitory Properties:

1. One laboratory test revealed that two pesticides, aldrin and simazine, were not inhibitory to the growth of nitrifying bacteria, Nitrobacter, whereas five other pesticides including chlordane, heptachlor, lindane, CIPC, and DDD prevented growth. Heptachlor was the most deleterious compound (E-99).

Organic Nitrogen Compounds

Many organic compounds contain nitrogen, commonly in the form of a carbon-nitrogen bond. Because of the numerous nitrogen oxidation levels, the chemistry of organic nitrogen substances is quite diverse. At its lowest oxidation state nitrogen forms amines. The most common amine is ammonia. Amines are classified according to the number of hydrocarbon groups attached to the nitrogen atom. Thus one substitution gives a primary amine, two substitutions give a secondary amine, three yields a tertiary amine, and four produces quaternary ammonium salts. Amines are generally soluble in water, and ionize, exhibiting varying pH dependent properties. At its highest oxidation state, nitrogen forms nitro compounds. These materials are chemically unstable, and are easily, and sometimes violently reduced (Trinitrotoluene, TNT, is a typical example). Nitrogen exists at intermediate oxidation states, each producing compounds with differing properties.

This plethora of nitrogen compounds exerts a wide range of environmental effects. While some nitrogen compounds are compatible with biological treatment, others are inhibitory. Some nitrogen is required for satisfactory treatment plant operation and a nitrogen source must be added to those trade wastes which are nitrogen deficient. Some organic nitrogen compounds are completely biodegradable, whereas others are toxic to wildlife and some are carcinogenic to man.

Organic nitrogen is contributed to sewage from domestic wastewaters which contain complex proteinaceous materials, from agricultural runoff, and from a variety of industrial operations.

Specifically, this class of compounds is used in the textile, dye, pharmaceutical, plastics, varnishes, perfume, insecticide, tanning, synthetic fibers, and solvents industries

Summary of Inhibitory Properties:

1. One investigator reports that 5 mg/l of acrylonitrile in sludge has an inhibitory effect on anaerobic digestion (E-109).

2. Another investigator reports that more than 20 mg/l of acrylonitrile in sludge is not harmful to anaerobic digestion (E-47).

3. 0.075 and 0.076 mg/l of thiourea have been reported by two investigators as inhibiting nitrification (E-109, E-129).

4. 0.14 and 0.18 mg/l of thioacetamide have been reported as inhibiting nitrification (E-109, E-129).

5. Analine at a concentration of 0.65 mg/l was found to inhibit nitrification by 75% (E-129).

6. At concentrations of 20-25 mg/l of TNT, aerobic processes were severly inhibited (E-33).

7. Increasing amounts of EDTA adversely effect settleability of secondary sludge and increases surface scum. At greater than 10 mg/l there is a decreased utilization of oxygen. At more than 25 mg/l there is a toxic effect on coliform bacteria (E-93). A concentration of 300 mg/l of EDTA has been found to inhibit nitrification by 75% (E-129).

8. Pyridine and the methylpyridines which occur in coke oven liquors are varied in the ability to inhibit nitrification (E-102) as follows:

	Concentration (mg/l)	% Inhibition of Nitrification
Pyridine	100	100
4-Methylpyridine	100	100
3-methylpyridine	100	No Effect
2-methylpyridine	100	40

Surfactants

This group of chemicals comprises those substances which have surface active properties. This includes synthetic detergents, emulsifiers, foaming agents, and wetting agents. These substances comprise normal constituents in domestic sewage, mostly associated with laundry detergents and commercial cleaning formulations. In addition, they are contributed by numerous industrial and commercial sources, including commercial laundries, wool scouring plants, dyeing, and rubber processing.

Surfactants may interfere with operation of a POTW in a number of ways. The surfactant may be inhibitory to biological processes because of its chemical properties. The surfactant may also interfere through various physical effects by causing excessive foaming, interfering with oxygen transfer or dispersing the biomass floc and causing loss of solids.

Summary of Inhibitory Properties:

1. Laboratory tests with the anionic surfactant Nacconol (at 100 mg/l) showed a stimulatory effect on the activated sludge process. At concentration levels greater than 200 mg/l, inhibitory effects were noted. These effects were worse at low pH (about 5) and low sludge loadings (E-63).

2. In another laboratory test with the cationic surfactant Ceepryn, 100 mg/l of this material suppressed oxygen uptake. The effect was more deleterious at high pH (about 9) (E-63).

3. In a pilot plant study, it was noted that 10 mg/l of an alkyl benzene sulfonate (ABS) surfactant had a negligible effect on the activated sludge process. It was reported that higher concentrations can be very inhibitory (E-61).

4. In another test, 10 and 20 mg/l levels of ABS caused minor losses (5 to 8%) in BOD removal efficiency in the activated sludge process. In the same study, a linear alkyl sulfate (LAS) at 10 and 20 mg/l caused a loss of only one to two percent BOD removal in the activated sludge process (E-50).

5. A laboratory study determined that a surface active agent at concentration levels from near zero to 50 mg/l interfered with oxygen transfer to water (E-92).

6. Digestion is likely to be seriously affected if the detergent concentration exceeds 2% of the weight of suspended solids. Initiation of digestion processes may be difficult at a detergent concentration of only 1% (E-109).

Miscellaneous Organic Chemicals

Benzidine

A laboratory experiment is reported which showed that 500 mg/l of benzidine inhibited oxygen uptake for 144 hours. At 5 mg/l, sludge activity decreased (E-10).

t-butyl Borane

In laboratory tests 500 mg/l of t-butyl borane was found to be inhibitory to activated sludge processes.

Formaldehyde

A level of 500 mg/l of formaldehyde was found to be stimulatory to activated sludge processes.

Benzene, Toluene, Xylene

Benzene and Xylene at the 1000 mg/l level are reported to seriously retard sludge digestion. Toluene at the 500 mg/l level has no appreciable effect on the process.

Oil and Grease

The term oil and grease covers a wide variety of substances that might be found in the influent to a POTW. Unlike other constituents, which usually have well defined chemical forms, oil and grease characteristics are usually dependent on the method by which the material is analyzed. Instead of oil and grease representing a specific chemical species, it is best defined as those organic substances with similar solubilities in a particular extracting solvent.

The most commonly used solvents for oil and grease analysis are hexane, petroleum ether and freon. These solvents will extract a broad spectrum of organic materials, including fatty acids, soaps, esters, fats, waxes and various petroleum products (E-131). Freon is specifically recommended by EPA as the solvent for oil and grease extractions. Consequently, it is essential that all oil and grease measurements be completed utilizing the freon method to assure uniformity of results.

Oil and grease is a natural constituent of sewage. It has been reported that fecal material contains more than 25%

grease (E-129). Additionally, domestic kitchen wastes contribute a large quantity of solvent extractable materials. Commercial or industrial sources of oil and grease include slaughter houses, food processers and restaurants, as well as automobile service stations and petroleum refineries or storage depots. Although oil and grease from all of these sources may be extracted by the same solvent, and therefore considered a single constituent, the substances included in the analysis may or may not be biodegradeable.

In general, the delineation between biodegradeable oil and grease and the more refractory extractable substances, corresponds to the distinction between oil and grease of animal and vegetable origin versus that of petroleum origin. Oil and grease of animal and vegetable origin has been reported to be more biodegradeable than that of petroleum origin (E-13). Nevertheless, many municipalities limit only total oil and grease (C-98). Traditionally, oil and grease concentration limits were focused on the prevention of sewer clogging and coating of pumping stations and treatment facilities, in which case the type of extractable material present was not important. However, distinguishing between petroleum and animal origin oil and grease can yield information on both oil and grease treatability and source.

Another factor to be considered in the impact on POTW operation is the distinction between the two physical forms of oil and grease, namely floatable and dispersed or dissolved material. Generally, many of the adverse effects experienced by POTW's, which are described below, result from the floatable portion of oil and grease present in wastewater. These problems can usually be avoided by employing gravity separation treatment techniques at the source. If such facilities are properly operated and maintained, floatable oil can be skimmed and thus kept out of the sewer system to a substantial degree.

In addition to partially passing through a biological treatment plant, petroleum oil at concentrations ranging between 50 and 100 mg/l has been reported to interfere with the aerobic processes in a POTW (E-23). It is believed that the principal interference is caused by attachment of oil, which has a density less than water, to the bacterial floc particles, which are to be gravity settled. The result is a slower settling rate, loss of solids by carryover out of the settling basin, and excessive release of BOD from the POTW to the environment (E-108). Additionally, in activated sludge units, oil and grease may coat the biomass, interfering with oxygen transfer. As a consequence of this "smothering" action, a lower degree of treatment may be achieved (E-130). Oil and grease may also interfere with the operation of physical-chemical treatment facilities by quoting the activated carbon and thus diminishing the adsorption of organic pollutants.

Oil and grease may also cause other problems in POTW operation. Actual operating problems have been reported in which oil and grease have clogged screens and interfered with skimming operations. Large quantities of oil and grease may block screens, scum draw-off systems and sludge pumps, causing excessive loads on mechanical scraping and cleaning devices. Excessive oil and grease may also cause serious problems in pumping station operation by fouling float systems so that pumps fail to operate, and by blocking pump intakes. Additionally, oil and grease may foul electrodes used for monitoring volatile and explosive mixtures, causing a serious hazard. Since wetwells are seldom pumped dry, the accumulation of floating oil and grease can cause operational problems in this portion of the system (E-130).

Among the more troublesome operational problems caused by oil and grease are those associated with anaerobic digestor operation. Oil and grease can be responsible for foaming throughout the plant and especially in digestor vessels. If oil and grease reaches a covered digestor, a crust may form on the underside of the cover, causing serious maintenance problems, and reducing the available digestor volume. Scum layers in digestors may also interfere with effective mixing, temperature control and gas separation (E-130).

An ordinance should provide a prohibition on floatable oil and grease, and a provision for a numerical limitation on oil and grease of mineral origin. In a majority of cases, if enforced, these requirements should provide adequate protection of treatment facilities and enable the municipality to meet NPDES permit requirements. In cases where the ordinance provisions are inadequate to meet NPDES permit conditions, the POTW would have three options:

1. establish a limitation on oil and grease of mineral origin more stringent than the proposed Federal pretreatment standards;

2. provide additional treatment at the municipal plant;

3. promulgate a limitation on total oil and grease concentration adequate to meet NPDES permit conditions.

Option 1 or 3 may require additional pretreatment by industrial contributors beyond gravity separation for the removal of oil and grease. If it is necessary to formulate a limit on total oil and grease concentration, or a more stringent standard for oil and grease of mineral origin, the POTW should not establish arbitrary numbers. Rather a systematic approach, such as utilization of the formula on page C-10, should be employed to develop equitable limitations appropriate for the particular system. Stringent oil and grease limits without a proper basis may result in unnecessary duplication of treatment provided at the POTW by industrial contributors.

Before deciding which option is most suitable, the municipality should conduct a sampling program to determine the existing level and characteristics of oil and grease concentrations in the treatment plant influent and effluent. The sampling program should establish the total oil and grease level, and delineate between oil and grease of mineral origin and that of animal and vegetable origin, to provide a basis for selecting the most appropriate course of action.

Discharge of Excessive Levels of Pollutants

Introduction

Sewage plant operations may be impaired by various types of shock loads. Shock loading has been defined as any rapidly occurring change in the chemical or physical environment of a plant's biomass caused by the introduction of a new pollutant, or a change in the rate of flow of a pollutant (E-73). Four specific types of shock loads are commonly encountered in POTW's:

1. Materials Deleterious at Trace Levels

The introduction of specifically deleterious materials such as metallic pollutants (copper, zinc, chromium, etc.) at trace levels has a well defined impact on treatment plant operation. These materials interfere with the metabolic activities within the biomass cells. Because of the precise nature of this type of shock load, it is possible to set down in advance the maximum acceptable concentration for such pollutants.

2. Qualitative Shock Loads

It has been reported that if a treatment system has become acclimated to a pollutant, the introduction of a new type of organic load can block the assimilation of the waste that the system was treating (E-89). This type of shock load is termed Qualitative (E-73), and may be caused by the introduction to a system of a new waste which would normally be biologically treatable.

3. Quantitative Shock Loads

Quantitative shock loads may be characterized as any sudden changed in the BOD loading that a plant receives. Since the type of BOD loading is not changed, as in the case of qualitative shocks, the result is an inability of the POTW to treat all of the increased amount of organic matter entering the plant. Quantitative shock loads are often called Excessive Discharge to the POTW, and generally refer to the introduction of unusually large amounts of BOD to the system. Other oxygen demand parameters such as COD or TOC may be used to describe quantitative shock loads, but BOD is the most common measure of organic loading and therefore its use offers the most general description of the phenomenon.

4. Hydraulic Shock Loads

Hydraulic shock loads are generally characterized by a rapid decrease in the concentration of the waste or organic loading of the system (E-73). Such a decrease in loading may result from the sudden introduction of relatively clean stormwater into the system, as is common with combined sewers. It should be noted that the initial portion of runoff from rainfall or "first flush" in a combined sewer may contribute a large quantity of organic matter, actually increasing the BOD loading as the flow simultaneously increases. Hydraulic shock loads often cause operating difficulties in POTW's resulting from the washout of solids from either primary or secondary sedimentation tanks.

Impact of Excessive Discharge and Shock Loading on POTW Operation

Contributions of trace deleterious materials and qualitative shock loads pose a relatively small, although significant, problem to the POTW operation. These two types of treatment interference can be controlled if the municipality places an upper limit on the quantity of the material that would be acceptable. However, for quantitative shock loading and hydraulic shock loading, setting limits is not straightforward. Several specific problems arise when trying to define an approach to controlling these two types of plant disruption. Each POTW is designed to treat a specific maximum amount of loading. Most POTW's are operating at levels which are either above or below design capacity, and each may be designed to handle differing diurnal flow patterns. Because of the heterogeneous nature of POTW operations and waste flows it becomes very difficult to predict in advance what kind of transient loads a POTW can handle. Some work has been completed in this area, and one investigator states that hydraulic shock loads of up to 100% above normal flow can be accepted without serious disruption of plant operations (E-71). Another researcher has presented a kinetic model that may enable some operators to predict the response of treatment plants to quantitative shock loads (E-72).

The apparent lack of data on approaches to handling excessive discharges points out that more research into this area is needed. A first order of priority should be the development of a firm definition of what constitutes excessive discharge or shock loading, and how differing plant conditions alter the effects of these types of plant upsets. For the short term, certain remedial steps can be taken by plant operators that will reduce the impact of excessive discharge. Wherever possible, industrial contributors should be required to implement equalization of concentrated organic wastes so that they can be released at low flow periods. Additionally, an effort should be made to regulate industrial sources of stormwater. Quite often, industrial facilities discharge stormwater, collected on their plant property, to sanitary systems that otherwise do not carry stormwater.

To avoid hydraulic overloading, the municipality should discourage this type of activity when practiced indiscriminately. However, the typical industrial stormwater may be contaminated, and consequently not of high enough quality to be discharged to a navigable water directly. Industries should be required to segregate runoff within the plant, providing for the direct discharge of clean stormwater. Contaminated runoff should be collected and stored for subsequent discharge to the sewer. Equalization of contaminated stormwater for discharge during low flow periods should decrease the possibility of hydraulically overloading the POTW, and should be strongly encouraged as a solution to this problem.

Other Substances Which Interfere with POTW Facilities

This category includes those substances which may interfere with the operation of a sewage treatment system, but which are not necessarily inhibitory to biological processes. Typical substances of this class include corrosive materials, substances which cause blockages in sewer lines and flammable or explosive materials. Although these materials may not inhibit biological processes, they can cause serious disruptions of treatment system operations. In the case of corrosive or explosive substances, severe damage to collection or treatment facilities may result from their introduction into the system. Consequently, corrosive or explosive materials, as well as substances that may cause sewer line blockages, are generally totally excluded from POTW systems by ordinance. Unlike trace inhibitory materials that may be tolerable, or even beneficial at low levels, the prohibited materials included in this section should be closely regulated because of the severity of their effect on treatment and collection systems.

Corrosive Materials

Corrosion in relation to sewerage systems can be defined as the phenomenon in which a pipe ,conduit ,or piece of equipment is gradually deteriorated by the fluid with which it comes in contact.

For sewage collection systems, one of the most prevalent types of corrosion is a deterioration of concrete pipe called "crown" corrosion. In this process, sulfates in wastewater are reduced under anaerobic conditions to sulfides, which hydrolyze to hydrogen sulfide. In addition, an industry such as an oil refinery or textile manufacturer may discharge sulfides directly to the sewer. If the concrete pipe is only partially filled, the H_2S formed may diffuse into the air above the fluid, where the bacteria Thiobacillus can convert it to sulfuric acid. Sulfuric acid then reacts with the calcium oxide in the concrete, forming calcium sulfate or gypsum. This material is structurally unsound, and will eventually crumble.

Coating the interior of concrete pipes with an inert material can avoid crown corrosion, but an equally effective preventative measure is the exclusion of sulfides from the collection system. Chlorinating sulfide carrying industrial wastewater is one way of achieving this goal. However, when the wastewater contains sulfate, which may be present as a result of non-carbonate hardness in the water supply, anaerobic conditions in the sewer should be avoided since they provide the necessary atmosphere for the creation of H_2S. Nevertheless, anaerobic conditions may be unavoidable in many instances. In those cases, proper sewer ventilation is necessary not only to provide a measure of safety from potentially lethal hydrogen sulfide, but also to avoid the oxidation of H_2S to sulfuric acid. Although sulfide may be beneficial in terms of precipitating metals, its presence should be closely monitored to avoid crown corrosion.

The second type of corrosion is the dissolution of metallic pipes and structures. This commonly occurs when wastewater has a low pH, or contains some other oxidizing agent. Generally, waste mixtures should be pretreated to fall in the pH range of 6 to 9. Lower pH (acidic) discharges will attack and disintegrate metal and concrete pipes and structures. Higher pH values are more tolerable, and enforcement of the high pH restriction should be at the discretion of the POTW operator. High fluoride levels, especially in acidic solutions, are a potential corrosion threat. High concentrations of chlorine, hypochlorites and chlorides are all corrosive to metals.

Many other products, when reacted with water will form acidic products which are detrimental to sewer systems. For example, acetic anhydride will hydrolize to form acetic acid; acetyl chloride will form acetic and hydrochloric acids, and ferric chloride will release hydrochloric acid upon hydrolysis. Sulfur dioxide and sulfurous acid are also common materials corrosive to sewers and sewage treatment plants.

Materials Which Cause Sewer Blockages

Discharges from commercial and industrial establishments must be controlled to prohibit materials which will clog sewers or treatment plants, or form deposits that adversely affect a sewer's hydraulic characteristics. Precipitates such as ferric hydrous oxide can interfere with the activated sludge system by inhibiting oxygen or food transfer between sludge particles and the surrounding liquids. Sulfates and carbonates can react with calcium salts to form a scale which can coat and ultimately block pipes. Fatty acids similarly react with calcium salts to form a curdy scum which can coat and block sewer lines.

Very high levels of suspended solids can cause blockages in sewer lines and overload primary settling tanks. Small fibers from textile industry operations may interfere with screens and filters by matting and blocking the passage of wastewaters.

Grease accumulation can cause sewer line clogging both in the collection system and in the interconnecting sewers within the POTW. Collection systems with restuarant connections are especially prone to blockages, unless suitable grease collection facilities are provided at the contributing source. Sewer clogging is most prevalent in small sewer lines, such as laterals, with 12 inch or smaller diameters. To cause a blockage problem, oil and grease which is typically discharged in a liquid or emulsion form, must congeal or solidify. Generally, the temperatures encountered in sewers are high enough to prevent solidification of oil and grease of petroleum origin (hydrocarbon type). However, oil and grease of animal or vegetable origin can exhibit a broad range of congealing temperatures. Some oils and greases of animal or vegetable origin will congeal at the highest temperatures encountered in sewers, while others may remain fluid at the lowest temperatures. The probability that oil and grease will congeal in a sewer pipe depends on a number of factors including the type of oil and grease involved, temperature and the fluid velocity in the pipe. A sufficiently high velocity in the sewer can prevent clogging by keeping all congealed material in suspension, even if all other conditions are appropriate for solidification.

Explosive and Flammable Materials

The discharge of potentially explosive or flammable materials to sewer lines must be strictly controlled. A serious hazard can be created by hydrocarbon solvents, which float on the surface of water, and exert their full vapor pressure on the air space above. Such substances as gasoline, kerosene, naphtha, benzene, toluene and xylene therefore, are particularly hazardous. Ethers, alcohols, ketones, aldehydes and organic peroxides similarly pose fire or explosion hazards.

Powerful oxidizing substances such as peroxides, chlorates, perchlorates and bromates are potentially dangerous and should be restricted. Substances which can liberate flammable or explosive gases such as carbides, hydrides, and sulfides must also be carefully controlled.

Many of the above chemicals originate from facilities that manufacture or use organic chemicals. POTW's with such facilities among their contributors should give special attention to the control of explosive or flammable materials. The production of methane in sewers resulting fron anaerobic conditions also presents a well known potential explosion hazard. Because of the potential hazards caused by the presence of explosive materials in sewers, extreme care should be taken whenever entering a sewer manhole.

Environmental Considerations

Sludge Disposal or Utilization

Interference with the biological unit processes of a POTW does not represent the only, or necessarily the most significant impact of industrial contributions. The sludges produced during the course of biological treatment will generally contain, in a concentrated form, many of the pollutants contributed to the POTW that may be considered inhibitory. Likewise, if pretreatment of industrial wastes is practiced, many of the undesirable industrial constituents undoubtedly will be concentrated in the industrial sludge. Those responsible for disposing of these sludges should be aware of the potential impact of industrial wastes (A-20). Of most concern are those pollutants that are generally considered deleterious to the environment. Specifically, the so-called "heavy metals" and various chlorinated hydrocarbons, such as polychlorinated biphenyls are of major concern.

Depending on the sludge disposal or utilization method employed, potentially harmful materials in sludges may have varying effects. Four methods of sludge disposal or utilization are currently in common practice. These methods include (1) land application, (2) disposal in sanitary landfills, (3) ocean dumping and (4) incineration (A-20, E-132, E-134).

Spreading sludges on land is generally considered a sludge utilization method, since the sludge acts as a source of nutrients or as a soil conditioner. Since this method may result in the contamination of food, however, extreme caution should be exercised. Because the wastewaters from certain industries contain concentrations of potentially harmful elements such as zinc, copper, nickel, cadmium, boron, lead or mercury which are concentrated in the sludge, it is important to be aware of the possible effect of these substances on the environment (E-133). Although trace levels of many of these elements are essential to plant growth, adding to the natural elements already present may lead to harmful concentrations.

High concentrations of many of the substances mentioned above have been noted in sludges derived from purely domestic wastewaters. Undoubtedly, metals in such systems originate from relatively uncontrolled sources. Corrosion of metallic plumbing elements in soft water areas may be such a source, as is storm water runoff in urban areas having combined sewer systems. Consequently, the introduction of industrial wastewater containing incompatible pollutants may intensify the problem. Special attention must be paid to details such as the cation exchange capacity of the soils upon which the sludge is placed, and the general chemistry of the runoff and ground water likely to be encountered.

Sanitary landfill operations pose similar problems for disposal of sludges from POTW's with significant industrial wastewater components. Proper precautions must be taken to adequately protect the environment from the impact of such sludges when applied to a landfill. The principal consideration in this regard is the leachate that is created by rainfall and runoff interacting with the sludge in the landfill. Metals and other substances present in the sludge are transferred to the leachate which in turn can adversely affect surface and ground water in the area. Consequently, control of leachate in landfills handling sludges with industrial waste components is of prime importance in the protection of the aquatic environment.

Incineration of sludges containing incompatible pollutants can also cause environmental problems. Incineration of such sludges may create a serious air pollution problem. This situation is not limited only to the volatilization of heavy metals or chlorinated hydrocarbons, but to other substances as well. The increasing use of incineration for sludge disposal in the recent past highlights the importance of proper consideration of potential air pollution problems. The design of such facilities must provide adequate safeguards to assure that the stack gases will comply with Federal, State and local air quality and emission standards and will not cause an adverse impact on the environment.

Sludge may also be disposed of in the ocean. This method has been practiced on both the east and west coasts of the United States. East coast POTW's have utilized barges to transport sludge to areas in the ocean designated for dumping by the EPA and the Corps of Engineers. West coast POTW's have utilized long pipelines for ocean disposal of sludge. Ocean disposal of sewage sludge is currently regulated by the EPA, with permits being required for this operation. The environmental impact on the ocean of sludges from POTW's has been the subject of many studies in the recent past. The effect on the ocean of incompatible pollutants in sludge has been an integral part of these studies, which have led to the close control of ocean disposal currently being exercised.

Reuse of Wastewaters

Environmental considerations relating to the reuse of wastewaters from POTW's containing industrial contributions are similar to the factors involved in sludge disposal or utilization. The primary concern in the reuse of such wastewaters is the presence of incompatible pollutants from industrial wastes which may be deleterious to the environment. The variety of wastewater reuse practices currently employed result in a wide variation of associated environmental considerations.

The major categories of wastewater reuse are land application, in which either raw or treated wastewater is spread over a specific land area, and reuse involving recycle for domestic or industrial purposes. In the case of land application, reuse generally involves utilization of the wastewater for agricultural purposes. In addition, it also implies completion of the hydrologic cycle by return of the wastewater to the ground water aquifer. Consequently, the land application of raw or treated wastewater containing incompatible pollutants to a large degree involves the same basic concerns as delineated above for the land application of sludge.

In the case of direct land application of wastewater, particularly treated wastewater, the concentration of incompatible pollutants from industrial wastes being applied to the land may be lower than with sludge. In sludge, there is generally a concentration of such pollutants that occurs through removal in the wastewater treatment process and dewatering steps. However, many incompatible pollutants may only experience incidental removal in the treatment process, so that the quantity passing through the POTW is greater than that being removed. Additionally, the volume of treated effluent from a POTW greatly exceeds the volume of sludge generated. These two factors suggest that in many cases the net quantity of incompatible pollutants from industrial wastes being applied to the land may be greater with treated wastewater than with sludge. In any event, careful evaluation of all environmental factors must be made prior to embarking on a program of wastewater reuse by land application.

The recycling of treated wastewater varies from reuse for industrial purposes, to the return of the treated effluent to the domestic water supply either directly or indirectly. Concerns associated with the presence of incompatible pollutants in wastewater being reused in industrial facilities vary widely depending upon the specific circumstances of the application. Many such recycle schemes involve reuse of the wastewater for cooling purposes or for make-up to a closed cooling system. In most industrial situations, environmental considerations are more closely related to the ultimate disposition of the wastewater rather than the factors involved in the industrial reuse application.

The recycling of treated wastewaters to domestic water supplies by both direct and indirect methods is the area of greatest concern regarding the presence of incompatible pollutants from industrial wastes. In these applications the principal concern is public health, so that even trace quantities of many incompatible pollutants may be intolerable. The methods utilized for recycling vary from direct return to water supply impoundments, to indirect return via injection into the groundwater aquifer or discharge to a water course used for domestic purposes. In either case, the treated effluent is diluted so that trace quantities of incompatible pollutants may become undetectable. Nevertheless, it is possible that a build-up of refractory pollutants may occur with such recycling over an extended period of time. Consequently, it is imperative that POTW's with industrial wastewater components contemplating or practicing wastewater reuse for domestic purposes, exercise careful control over the incompatible pollutants present to avoid any possibility of a public health hazard.

SECTION F
REMOVAL AND PASS THROUGH OF POLLUTANTS IN PUBLICLY OWNED TREATMENT WORKS

Introduction

Data Collection
  Data Compilation

Data Analysis
  Limitations of Data Reported
  Plant Performance
  Characterization of Primary and Biological Plant Performance

SECTION F

REMOVAL AND PASS THROUGH OF POLLUTANTS IN PUBLICLY OWNED TREATMENT WORKS

Introduction

The purpose of this section of the report is to summarize available information on removal and effluent concentrations, or pass-through of pollutants in POTW's. It is intended to be responsive to the portion of Section 304(f) of PL 92-500 which states, "Guidelines under this subsection shall be established to control and prevent the discharge....(either directly or through publicly owned treatment works) of any pollutant which interferes with, passes through, or otherwise is incompatible with such works".

The information contained herein was obtained from a survey of POTW's having analytical data for influent and effluent concentrations of incompatible pollutants. Specific emphasis was placed on obtaining data on the concentration of metals in POTW systems. Data was obtained from a total of 269 treatment facilities for 61 pollutant parameters. Wastewater flow in the POTW's represented by the survey varied from less than 0.05 MGD to more than 110 MGD. The major portion of plants in the survey, a total of 101 POTW's,were in the range of 1.0 to 5.5 MGD,representing 38 percent of the total number of facilities reporting data. Computer facilities were utilized to summarize and analyze the data obtained. The summary computer reports are presented in Appendix 6 of these guidelines.

The discussion which follows describes data sources, procedures used in data compilation, limitations of the reported data, and plant performance evaluation for primary, trickling filter and activated sludge plants. A limited discussion of biological treatment plants with chemical addition and tertiary plants is also presented, along with the results of correlation and regression analyses for selected pollutant parameters. A characterization of the performance of primary and biological treatment plants (trickling filter and activated sludge) is presented in terms of percent removal and efffluent concentration (pass through) for the 17 most significant pollutant parameters.

The performance characterization results contained in this section, are presented only to provide guidance in determining pretreatment requirements where sufficient operational data is not available at a specific POTW. The data is not intended to serve as a substitute for detailed influent and effluent sampling of the treatment plant, which will provide the most reliable removal and pass through information for the system in question. However, the data does present removal and pass through information which may be considered typical of many conventional primary and biological treatment plants.

Data Collection

In accumulating data, an attempt was made to compile a broad base of valid removal and pass through information on various sewage treatment processes. An extensive search was undertaken covering data in the published literature and unpublished data collected by Federal, State and interstate agencies, and individual sewerage system operators. With the cooperation of the EPA Region II office, NPDES permit applications from publicly owned treatment works were evaluated as a potential source of removal and pass through data. It was concluded that permit applications were generally not a good source for this information.

However, another data source from the EPA regional offices, compliance monitoring reports, was identified as a significant source of removal and pass through information. Compliance monitoring reports are prepared by the EPA regional enforcement or State enforcement programs for POTW's with NPDES permits. These reports summarize the results of on-site monitoring, usually performed on a continuous basis for 24 or 48 hours. In some EPA regions, monitoring encompasses both influent and effluent streams, while in other regions only the plant effluent is sampled. In the regions where influent and effluent data were available, these reports were found to be an excellent data source in that they usually covered a wide range of pollutant parameters and were generally uniform in format.

Although the compliance monitoring program has just recently begun, these reports nevertheless represent about 40 percent of the total data base compiled. Most of the reports obtained were from EPA Regions V and VII, as their programs are well advanced, and both plant influent and effluent are sampled.

Interstate pollution control agencies, river basin commissions, State agencies, and individual sewer system operators were contacted in the data collection phase of the work. Most of the governmental agencies contacted did not compile removal or effluent data on parameters other than those normally associated with domestic sewage, except where it was known or suspected that industrial wastewater was interfering with or passing through the system. However, those State agencies and interstate commissions which did provide valid comprehensive data comprised about 50 percent of the total data base compiled. Individual POTW's and the published literature constituted only an estimated 10 percent of the compiled data. Most POTW's contacted were not sampling for comprehensive removal parameters on a routine basis. The literature was found to contain very little specific plant removal or pass through data on parameters other than those normally used for the analysis of domestic sewage.

Altogether, removal and pass through data was obtained from 269 plants, geographically distributed according to Report No. 1 of Appendix 6.

Data Compilation

Reported data was categorized according to treatment process, treatment flow rate, and percent industrial flow. Report No. 2 of Appendix 6 summarizes the treatment process and flowrate categories, most of which were used in grouping the data reported. Plant processes were categorized into five major classes as follows:

A - Primary Sedimentation Treatment Process
B - Trickling Filter
C - Activated Sludge
D - Filtration
J - Miscellaneous

Additional plant and sampling information was also collected. Report No. 3 of Appendix 6 details the sampling procedure, sampling date, major industrial contributors, and level of POTW control over industrial contributors. The sampling procedure is indicated as either flow proportioned composite (FC), time composite (C), or grab (G). If a composite sample was taken the sampling duration is then indicated. The final item shown under sampling procedure is (S) for simultaneous sampling at influent and effluent, or (R) for sampling performed with plant retention time taken into account. The sampling date is indicated as Year/Month/Day, and under the remarks column, the composite interval, or the method of data summary is indicated. Where the information was readily available, major industrial contributors and the level of POTW control over industry is also shown. The level of control is a subjective measure ranging from no control (O) to very tight control (10) with surveillance and monitoring.

Data was compiled according to STORET numbers for 61 parameters as indicated in Report No. 7 of Appendix 6. Computer processing was utilized in data handling and analysis, resulting in the reports shown in Appendix 6, and the correlation and regression analyses which follow.

Data Analysis

Analysis of accumulated data includes a discussion of the limitations of the data reported, analysis of 6 hour simultaneous sampling results, evaluation of plant performance data, and correlation and regression analyses for statistical relationships within the reported data.

Limitations of Data Reported

There are three major areas in which the data reported is limited; selection of plants, sampling variation, and plant performance variation. One governmental source of reported data indicated that in most cases their basis for selecting POTW's for sampling was that the plant was having, or was suspected of having, operating problems. This type of data has been excluded from the data compilation insofar as it could be recognized. However, the possibility of data bias toward malfunctioning plants should be noted. This could be particularly true with regard to data obtained from enforcement or compliance activities. Nevertheless, significant differences on a broad basis between data from compliance monitoring and that obtained from other sources was not noted.

Since the reported data was not obtained from a controlled survey, the method of sampling was therefore not consistent. It was suspected that data from 6 hour simultaneous sampling procedures might not be valid, because plant detention time was not taken into account. Report No. 4 of Appendix 6 was prepared to compare sampling results from 24 hour composites and 6 hour simultaneous composites for similar plants. It was expected that this comparison might show a higher level of removal with 6 hour sampling. This was not confirmed by the comparison, and, in fact, an opposite trend was exhibited in some instances. It was therefore concluded that the 6 hour, and all simultaneous sampling results, should be included in the reported data. However, since sampling methods could not be compared at a single plant, a potential data misrepresentation still exists due to sampling variation.

Plant performance variation is the greatest single area of data limitation. A single day's sample from what may be a highly variable plant operation may not accurately characterize the removal effectiveness of the plant in question. Much of the data obtained in the survey is of this type and therefore may be open to question on the basis of representativeness.

Insofar as possible, the reported data is for typical plant operation, and where more than one sampling was available, average values were reported. In several instances, a great deal of data was available for specific plants where specialized test programs are underway or thorough monitoring is performed on a routine basis. Average values for these facilities were utilized and entered as one data point for each pollutant parameter in the computer analysis. Consequently, several of the data points in the analysis are extremely representative of plant performance, but were compared on an equal basis with data far less representative. This is a possible additional limitation of the results reported. Nevertheless, a broad spectrum of plants was covered by this analysis and significant variation between the average results obtained and values reported for the plants with significant quantities of data was not noted.

Plant Performance

Report No. 5 of Appendix 6 is a summary of removal data for 40 parameters grouped by plant treatment process as follows: conventional primary plants (A1), other primary plants (A02), conventional trickling filter plants (B1), other trickling filter plants (B02, B04, B05), conventional activated sludge plants (C1), other activated sludge plants (C02, C05, C06, C09, C19, C20), and miscellaneous plants (D, J). It was concluded from this report that the conventional primary, trickling filter, and activated sludge plant groups could be expanded by incorporating the specialized categories of these processes into a summary type of analysis. Similarly, Report No. 7 of Appendix 6 is a summary of effluent or pass through data for all 61 parameters for plant groups as outlined above for Report No. 5.

In addition to the regrouping of plants under the expanded headings of primary, trickling filter, and activated sludge plants, upon review of Reports 5 and 7, it was also decided that the miscellaneous and "other" plants should be grouped as biological treatment plants with chemical addition, and tertiary plants. The following table summarizes the various treatment plant groups as discussed above, and defines the plant categories included in each group for further reference.

Report No. 6 of Appendix 6 is a summary of removal data for all primary, trickling filter and activated sludge plants not utilizing chemical addition. Additional plant groups also included in this report defined as "biological plants" include the sum of trickling filter and activated sludge plants; "secondary plants", those plants meeting the EPA definition of secondary treatment (an effluent BOD and SS less than or equal to 30 mg/l, and a removal of 85% or greater for both parameters); and "total all plants", the

TABLE F-1

DISTRIBUTION OF POTW DATA BY PLANT PROCESS

		Category	No. of Plants	
(PP)	Primary Plants	A01, A02	79	
(TFP)	Trickling Filter Plants	B01,B02,B04,B05	81	
(ASP)	Activated Sludge Plants	C01,C02,C05,C06,C09, C19,C20	83	
				243
(BPCD)	Biological Plants with Chemical addition	B03,C03,C04,C14	8	8
(TP)	Tertiary Plants	C07,C08,C10	3	
		D01,D02,D03,D04,D05, D06,D07	8	
				11
	Other Plants	A03,A04,A05	3	
		J01,J02	4	
				7
TOTAL				269

sum of all 269 plants' data. The number of plants reporting, the maximum and minimum percent removal, the mean removal, and the standard deviation of the removal data are given for each parameter under the plant groups discussed above. It should be pointed out that the number of secondary plants can not be related as a percentage of the number of biological plants because not all biological plants reported the data required for secondary plant selection. Report No. 8 of Appendix 6 is a summary of effluent or pass through data in a format similar to the removal report discussed above.

The removal and effluent data summary reports were utilized in a selection of parameters for more detailed examination. The criteria used in this selection were twofold; the importance of the parameter in the context of project objectives, and the number of plants for which data was reported. On this basis the following parameters were selected:

Cadmium	(CD)
Chromium	(CR)
Lead	(PB)
Mercury	(HG)
Copper	(CU)
Nickel	(NI)
Zinc	(ZN)
Iron	(FE)
Manganese	(MN)
Phosphorus-Total	(P-TOTAL)
Total Kjeldahl Nitrogen	(TKN)
Ammonia	(NH_3)
Phenolics	(PHEN)
Total Organic Carbon	(TOC)
Chemical Oxygen Demand	(COD)
Suspended Solids	(SS)
Biochemical Oxygen Demand, 5 Day	(BOD)

All the metallic parameters represent total concentrations rather than the soluble fraction of the metal. COD data represents the sum of COD values obtained by the three methods of analysis listed in Reports 6 and 8 of Appendix 6. Tables F-2 and F-3 are summaries of the removal and effluent or pass through data for the selected parameters. Figures F-1 thru F-17 are cumulative distribution curves of the removal and effluent data for the same parameters. The data utilized for these curves is presented in Tables 6-1 and 6-2 of Appendix 6.

Characterization of Primary and Biological Plant Performance

Table F-4 summarizes the removal and effluent or pass through data reported for primary and biological treatment

TABLE F-2
REMOVAL DATA SUMMARY
FOR PRIMARY, TRICKLING FILTER
AND ACTIVATED SLUDGE PLANTS (SELECTED PARAMETERS)

Parameter	Primary Plants (PP)				Trickling Filter Plants (TFP)				Activated Sludge Plants (ASP)			
	Mean	Standard Deviation	Max/ Min	No. of Plants	Mean	Standard Deviation	Max/ Min.	No. of Plants	Mean	Standard Deviation	Max/ Min.	No. of Plants
CD	8	17	76/0	31	20	25	75/0	35	17	27	88/0	44
CR	26	26	80/0	36	37	30	99/0	48	46	34	98/0	54
PB	24	26	88/0	34	37	31	93/0	41	39	32	95/0	49
HG	27	29	75/0	21	30	23	67/0	20	39	32	99/0	34
CU	26	24	77/0	44	54	24	95/0	49	57	24	95/0	63
NI	6	18	92/0	28	21	23	86/0	32	20	21	80/0	44
ZN	31	22	88/0	38	46	22	89/0	52	58	25	99/0	58
FE	40	22	89/0	27	50	26	90/0	30	63	27	98/8	35
MN	15	20	81/0	16	31	23	72/0	21	38	32	93/0	19
P-TOTAL	13	8	24/0	7	26	22	99/0	24	42	25	92/0	36
TKN	22	20	60/0	7	50	27	94/7	20	34	26	92/[illegible]	11
NH_3	20	16	64/0	42	41	30	99/0	48	49	31	99/[illegible]	47
PHENOL	38	-	50/25	2	50	28	85/0	12	69	31	98/0	16
TOC	24	19	56/0	30	64	18	84/8	23	73	12	89/42	13
COD	26	-	82/0	18	71	-	95/34	36	75	-	94/24	40
SS	51	18	92/17	47	75	19	97/20	66	75	22	99/9	62
BOD	30	22	89/0	52	77	18	96/5	60	84	15	99/18	65

Notes:

1. PP = A01, A02 plants (Ref. Appendix 6, Report No. 2)
2. TFP = B01, B02, B04, B05 (Ref. Appendix 6, Report No. 2)
3. ASP = C01, C02, C05, C06, C09, C19, C20 (Ref. Appendix 6, Report No. 2)

TABLE F-3
EFFLUENT DATA SUMMARY
FOR PRIMARY, TRICKLING FILTER
AND ACTIVATED SLUDGE PLANTS (SELECTED PARAMETERS)

Parameter	Primary Plants (PP)				Trickling Filter Plants (TFP)				Activated Sludge Plants (ASP)			
	Mean	Standard Deviation	Max/Min	No. of Plants	Mean	Standard Deviation	Max/Min	No. of Plants	Mean	Standard Deviation	Max/Min	No. of Plants
CD (µg/l)	14	9	40/3	35	11	10	66/1	41	50	277	1970/1	48
CR "	188	406	2600/6	40	235	563	3200/3	52	202	515	2520/5	60
PB "	156	272	1700/10	37	116	276	1800/5	45	67	68	350/3	51
HG "	1.0	1.3	5.0/0.1	23	1.0	2.0	10.0/0.1	22	6.0	32	200/0.1	37
CU "	191	278	1700/10	48	133	203	1800/3	54	92	195	1600/8	68
NI "	165	387	1700/6	33	198	336	1533/7	38	165	387	1700/6	56
ZN "	550	658	3600/30	49	316	464	2800/40	57	238	257	1400/10	66
FE "	1520	1020	5000/400	30	2910	11000	65600/100	34	747	1170	6800/100	37
MN "	176	112	390/30	22	136	130	580/20	28	144	200	940/10	23
P-TOTAL (mg/l)	12.9	22	77/1.3	10	9.02	3.8	18.3/3.3	27	5.2	2.7	10.4/1.0	40
TKN "	24.4	11.6	47/8.5	-	16.8	11.9	47.8/1.2	21	19.0	9.6	34/1.5	12
NH_3 "	20.2	34.6	256/2.1	63	16.6	17.2	115/0.03	65	11.1	7.6	27.5/0.07	63
PHENOL (µg/l)	16	23	53/0.1	-	209	772	3000/0.03	13	135	473	2000/0.02	16
TOC (mg/l)	142	84.2	539/52	35	54.3	26.3	129/23	23	35.3	22.4	95.0/10	14
COD "	346	-	768/58	19	133	-	361/18	38	86	-	275/14	42
SS "	93	62	314/15	54	43	37	228/5	66	37	39	185/2	64
BOD "	167	111	650/20	58	48.6	47.3	245/4.0	61	28.3	40.7	230/2.0	65

Notes:

1. PP = A01, A02 Plants (Ref. Appendix 6, Report No. 2)
2. TFP = B01, B02, B04, B05 (Ref. Appendix 6, Report No. 2)
3. ASP = C01, C02, C05, C06, C09, C19, C20 (Ref. Appendix 6, Report No. 2)

TABLE F-4
CHARACTERIZATION OF PRIMARY AND BIOLOGICAL PLANT PERFORMANCE

Parameter	Primary Plants (PP)		Biological Plants (BP)	
	Percent Removal (50% ≥)/(mean)	Effluent Concentration (50% <)/(mean)	Percent Removal (50% ≥)/(mean)	Effluent Concentration (50% <)/(mean)
CD (µg/l)	7/8	11/14	9/18	10/30
CR "	16/26	90/188	41/42	50/218
PB "	20/24	110/156	41/38	60/92
HG "	22/27	0.6/1.0	38/35	0.6/3.5
CU "	18/26	110/191	56/56	50/113
NI "	6/6	75/165	16/21	65/182
ZN "	26/31	300/550	52/52	160/277
FE "	35/40	1300/1518	59/57	600/1827
MN "	8/15	160/176	28/35	90/140
P-TOT (mg/l)	ID/13	10/13	32/34	6/7
TKN "	ID/22	ID/24	40/42	17/18
NH$_3$ "	17/20	13/20	37/45	12/14
PHEN (µg/l)	ID/38	ID/16	68/60	2.5/175
TOC (mg/l)	20/24	125/142	71/69	45/25
COD "	18/26	340/346	75/73	100/110
SS "	50/51	78/93	80/75	30/40
BOD "	28/30	140/167	85/81	28/39

Notes:

1. ID = Insufficient data reported.
2. PP = A01, A02 (Ref. Appendix 6, Report No. 2)
3. BP = TFP + ASP = B01, B02, B04, B05, C01, C02, C05, C06, C09, C19, C20.

plants. Removal data has been reported as the mean and the removal equalled or exceeded by 50% of the plants reporting, as estimated from Figures F-1 thru F-17. The estimated 50% value should be considered an approximation of the median, since a graphical determination does not meet the statistical definition of median. Similarly, effluent data has been reported as the mean and the effluent concentration which has not been equalled or exceeded by 50% of the plants reporting, as estimated from Figures F-1 thru F-17.

Table F-4 and the figures show that the removal of metals in primary plants was generally low, with cadmium, nickel and manganese having the lowest removals. Mean effluent concentrations were 14 µg/l for cadmium, 165 µg/l for nickel and 176 µg/l for manganese. Removal of chromium, lead, copper and mercury was somewhat higher, while zinc and iron removals were the highest of the metals in primary plants. Mean effluent concentrations were 550 µg/l for zinc, and 1518 µg/l for iron.

In biological treatment plants, cadmium, nickel and manganese were removed least, with chromium, lead, copper and mercury removals being slightly higher. Mean effluent concentrations of up to 30 µg/l for cadmium, 182 µg/l for nickel, and 140 µg/l for manganese were reported. Zinc, iron, and copper had a relatively high percentage of removal in biological treatment plants. Mean effluent concentrations of up to 277 µg/l for zinc, 1827 µg/l for iron, and 113 µg/l for copper were reported. These data would tend to indicate that iron, zinc and copper are most susceptible to removal in conventional treatment facilities, while cadmium, nickel and manganese are the least susceptible of the metals to removal.

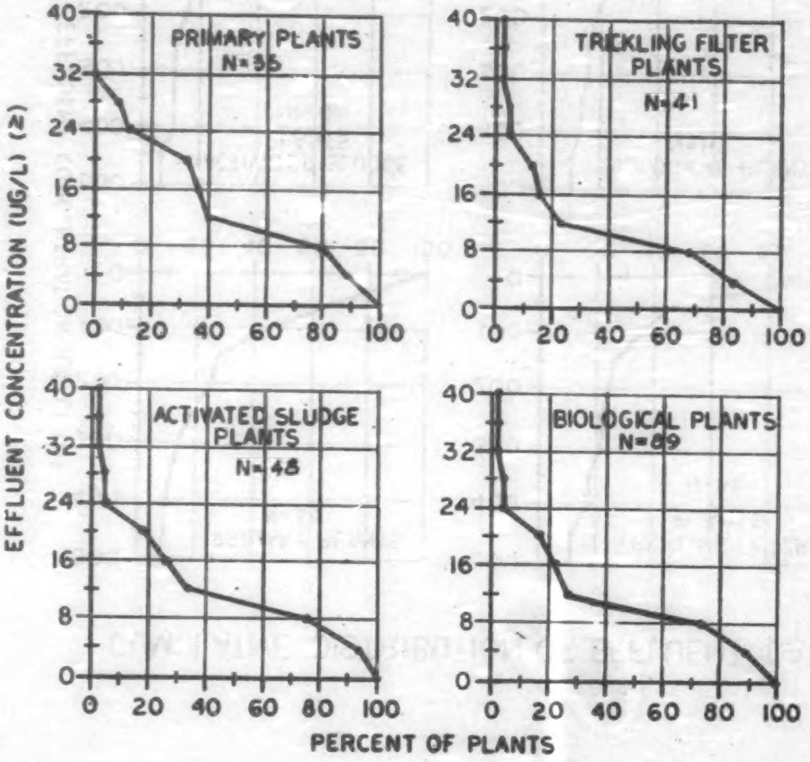
The removal of pollutant parameters related to organic pollution, total phosphorus, kjeldahl nitrogen, ammonia, and phenolics in primary plants was on the order of 13 to 38 percent. Mean effluent concentrations of 13 mg/l for P-TOT, 24 mg/l for TKN, 20 mg/l for NH_3 and 16 µg/l for phenolics were reported. In biological plants, the removals for these parameters were on the order of 32 to 65 percent. Mean effluent concentrations of 7 mg/l for P-TOT, 18 mg/l for TKN, 14 mg/l for NH_3, and 175 µg/l for phenolics were reported.

The removal of the more general parameters of pollution, TOC, COD, SS, and BOD in primary plants was on the order of 18 to 51 percent. Mean effluent concentrations of 142 mg/l for TOC, 346 mg/l for COD, 93 mg/l for SS, and

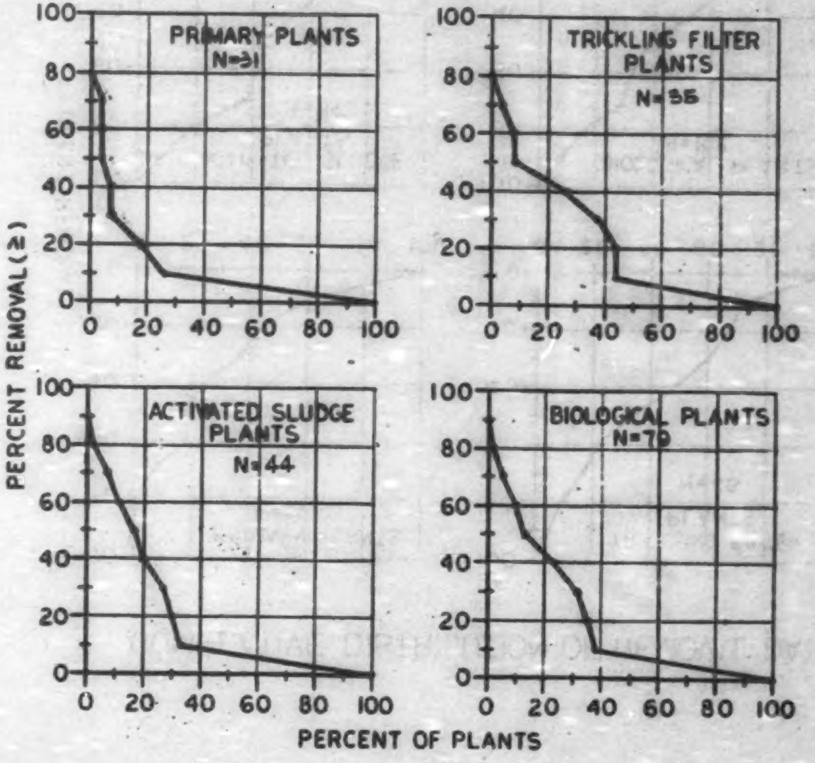
167 mg/l for BOD were reported. Removals of these parameters in biological plants were on the order of 69 to 81 percent, with mean effluent concentrations of 25 mg/l for TOC, 110 mg/l for COD, 40 mg/l for SS, and 39 mg/l for BOD.

FIGURE F-I
CADMIUM

CUMULATIVE DISTRIBUTION OF EFFLUENT DATA



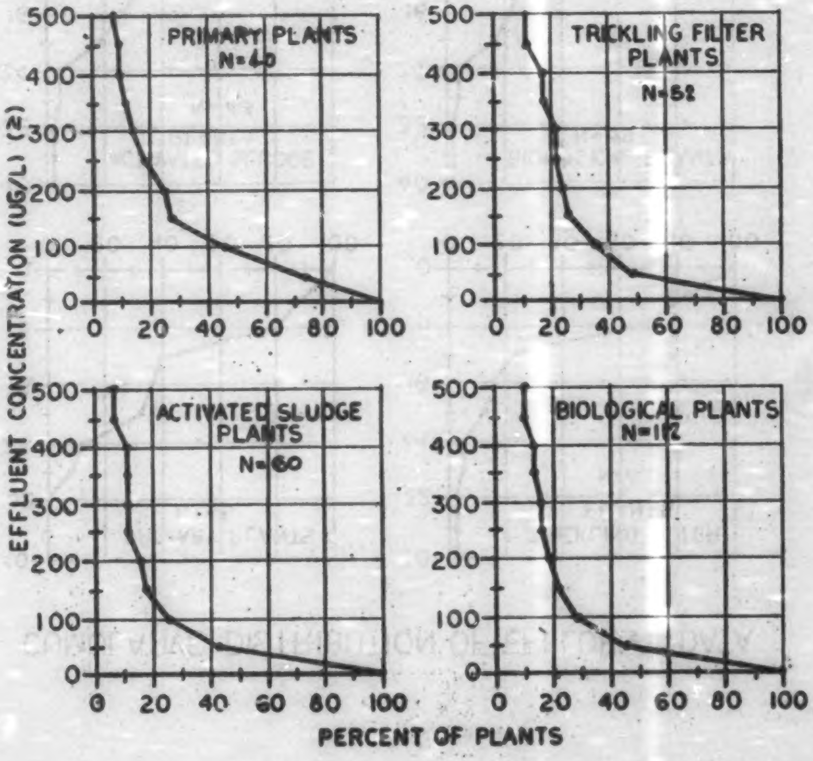
CUMULATIVE DISTRIBUTION OF REMOVAL DATA



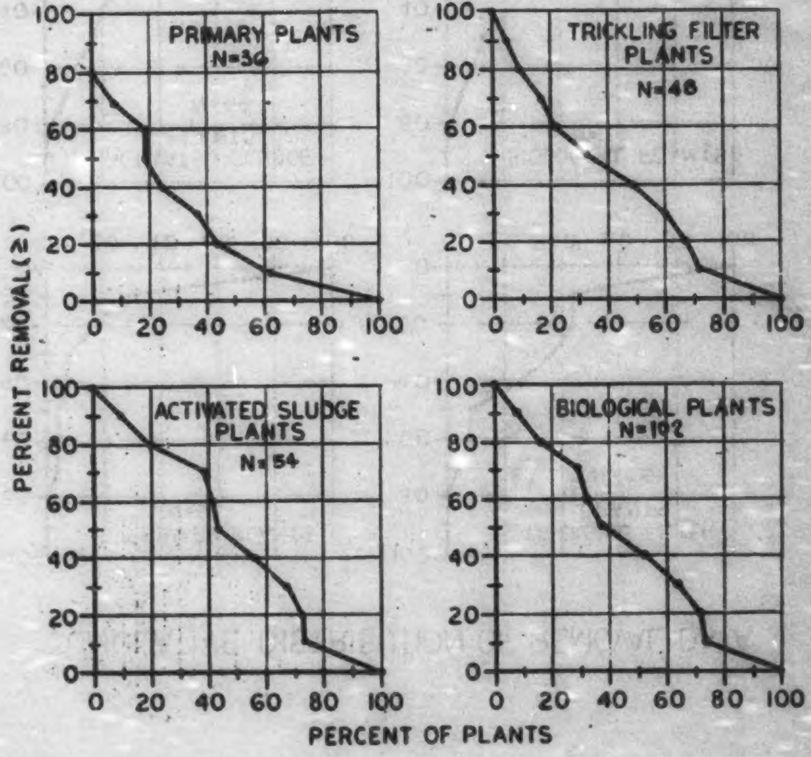
NOTES:-1-"N" IS THE NUMBER OF PLANTS REPORTED
2-"BIOLOGICAL PLANTS" IS THE TOTAL OF TRICKLING FILTER & ACTIVATED SLUDGE PLANTS
3-CADMIUM REPORTED AS CD, TOTAL

FIGURE F-2
CHROMIUM

CUMULATIVE DISTRIBUTION OF EFFLUENT DATA

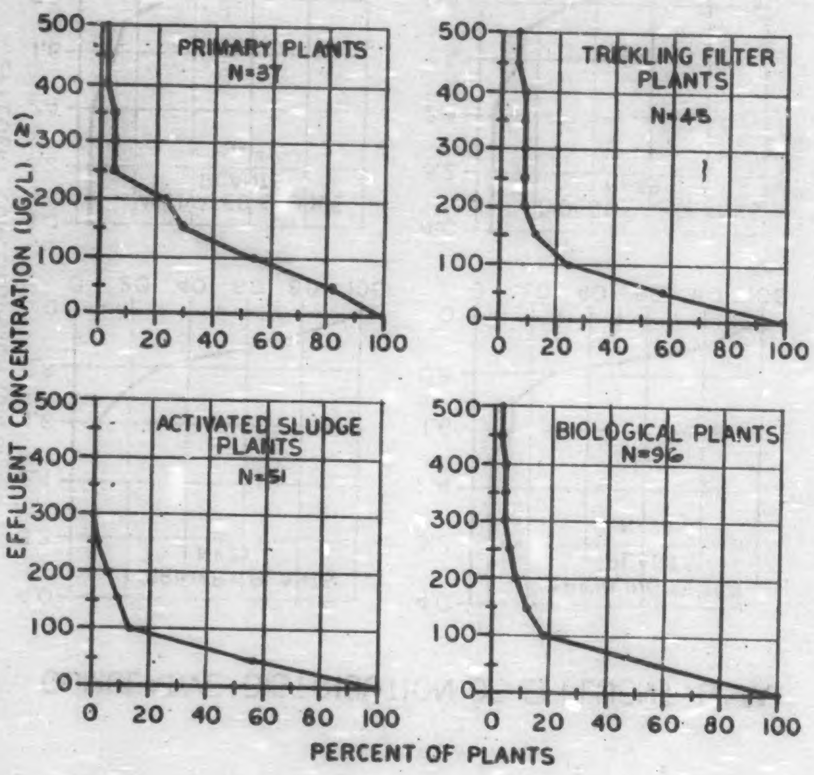


CUMULATIVE DISTRIBUTION OF REMOVAL DATA

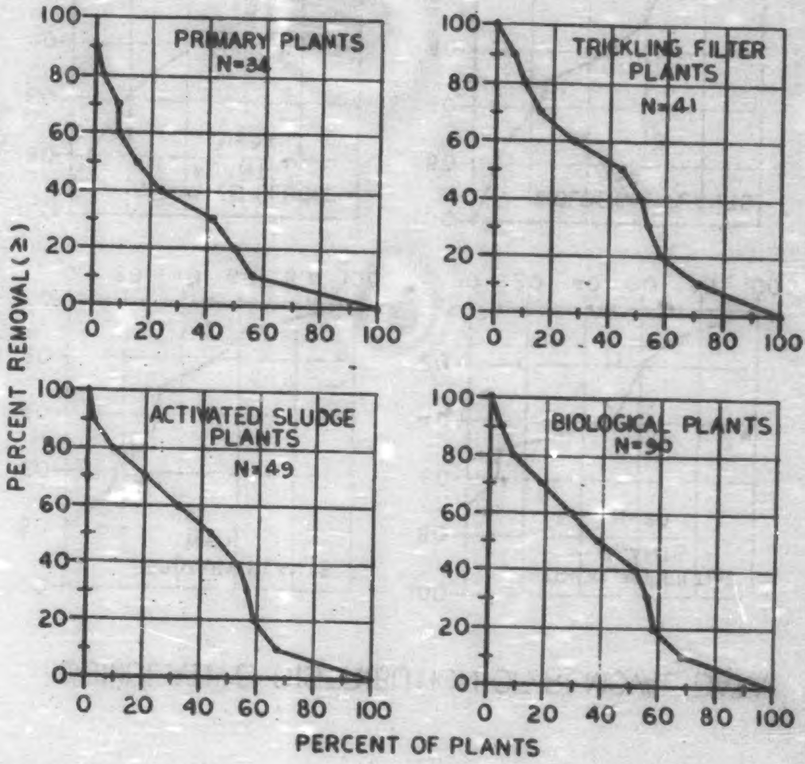


NOTES:- 1-"N" IS THE NUMBER OF PLANTS REPORTED
2-"BIOLOGICAL PLANTS" IS THE TOTAL OF TRICKLING FILTER & ACTIVATED SLUDGE PLANTS
3-CHROMIUM REPORTED AS CR, TOTAL

CUMULATIVE DISTRIBUTION OF EFFLUENT DATA



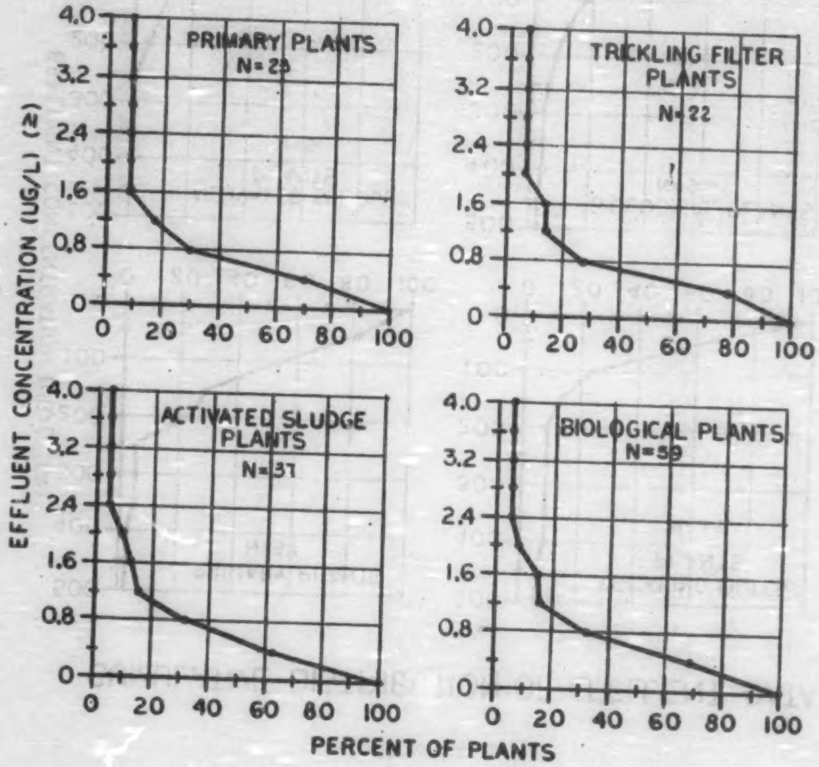
CUMULATIVE DISTRIBUTION OF REMOVAL DATA



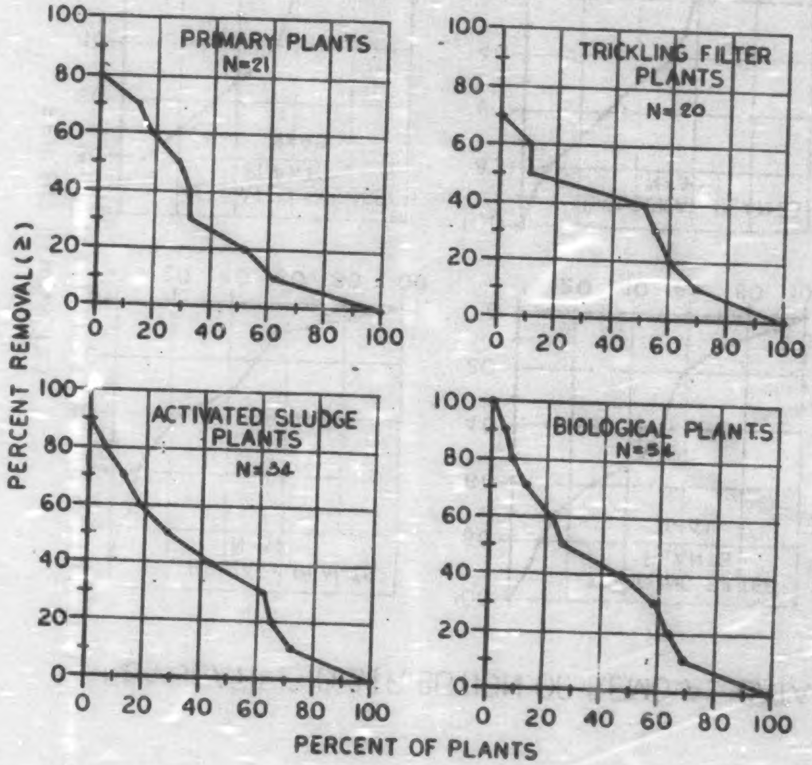
NOTES:-1-"N" IS THE NUMBER OF PLANTS REPORTED
2-"BIOLOGICAL PLANTS" IS THE TOTAL OF TRICKLING FILTER & ACTIVATED SLUDGE PLANTS
3-LEAD REPORTED AS PB, TOTAL

FIGURE F-4
MERCURY

CUMULATIVE DISTRIBUTION OF EFFLUENT DATA

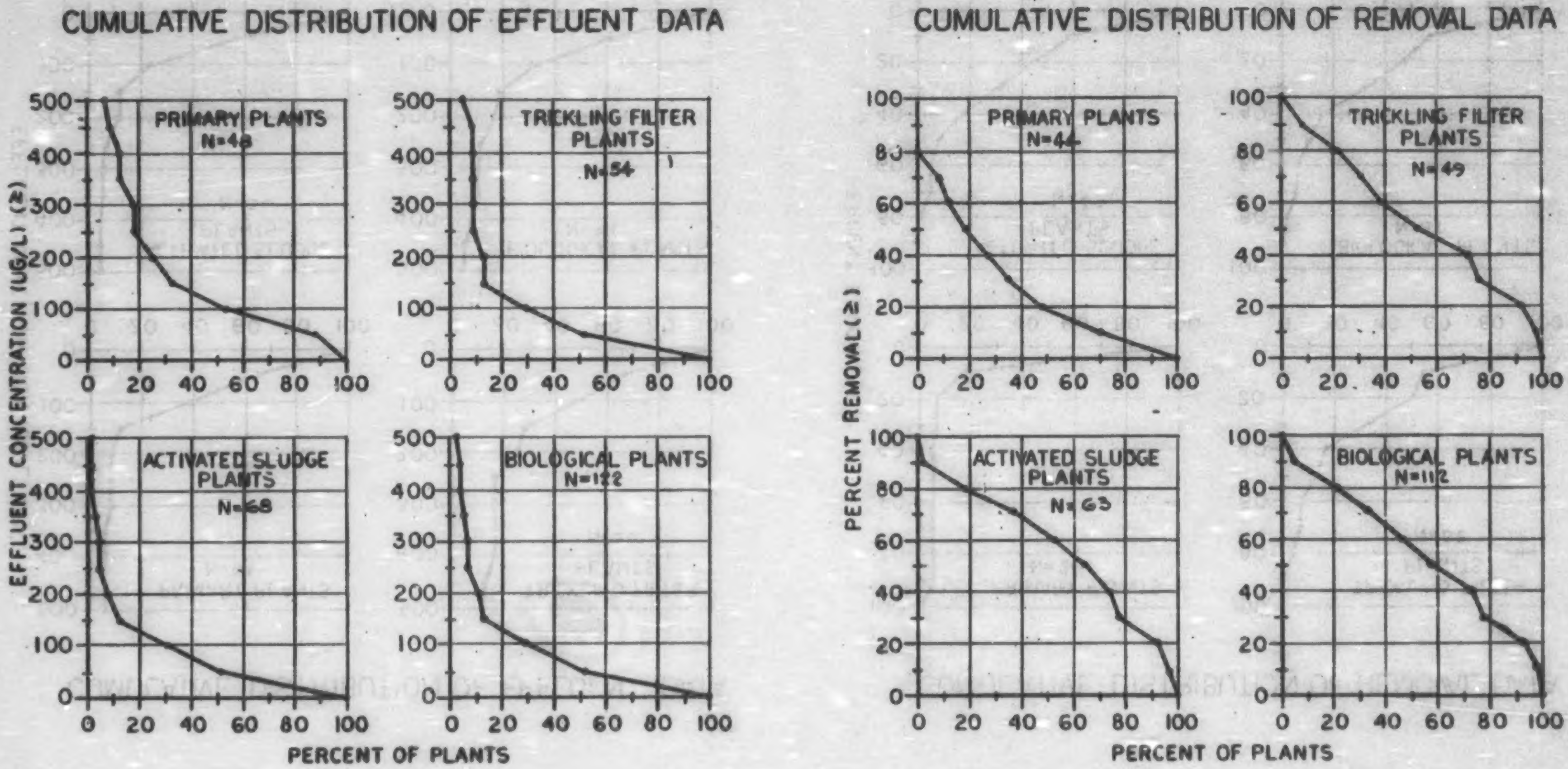


CUMULATIVE DISTRIBUTION OF REMOVAL DATA



NOTES:-1-"N" IS THE NUMBER OF PLANTS REPORTED
2-"BIOLOGICAL PLANTS" IS THE TOTAL OF TRICKLING FILTER & ACTIVATED SLUDGE PLANTS
3-MERCURY REPORTED AS HG, TOTAL.

FIGURE F-5
COPPER

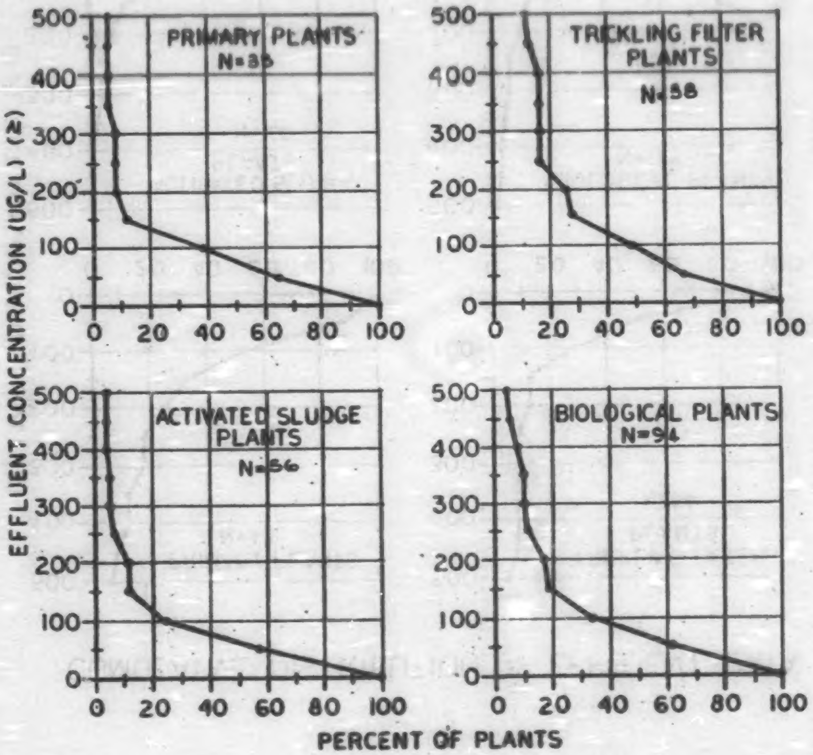

CUMULATIVE DISTRIBUTION OF EFFLUENT DATA

CUMULATIVE DISTRIBUTION OF REMOVAL DATA

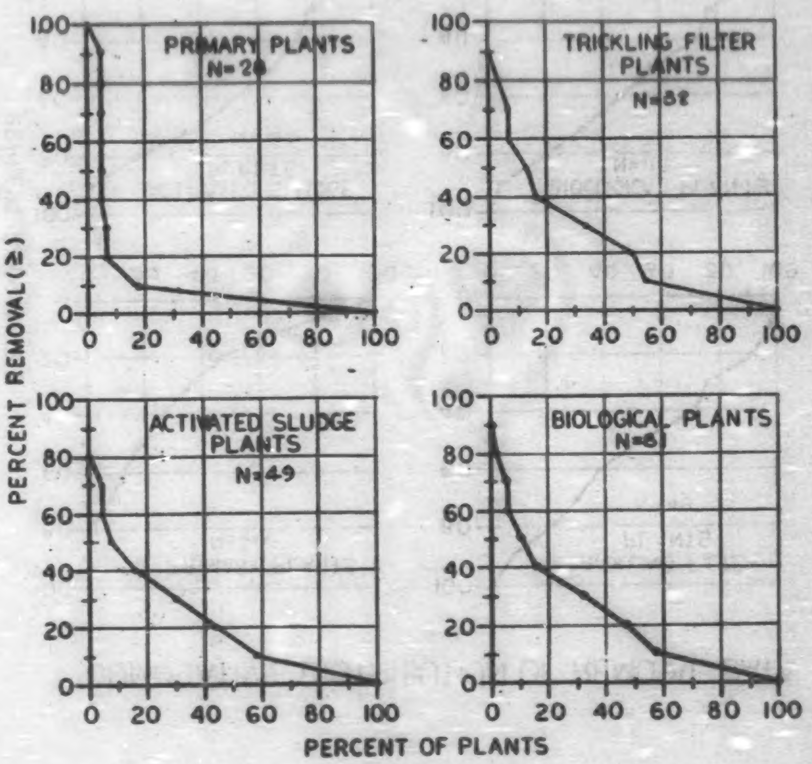
NOTES:-1-"N" IS THE NUMBER OF PLANTS REPORTED
2-"BIOLOGICAL PLANTS" IS THE TOTAL OF TRICKLING FILTER & ACTIVATED SLUDGE PLANTS
3-COPPER REPORTED AS CU, TOTAL

FIGURE F-6
NICKEL

CUMULATIVE DISTRIBUTION OF EFFLUENT DATA



CUMULATIVE DISTRIBUTION OF REMOVAL DATA

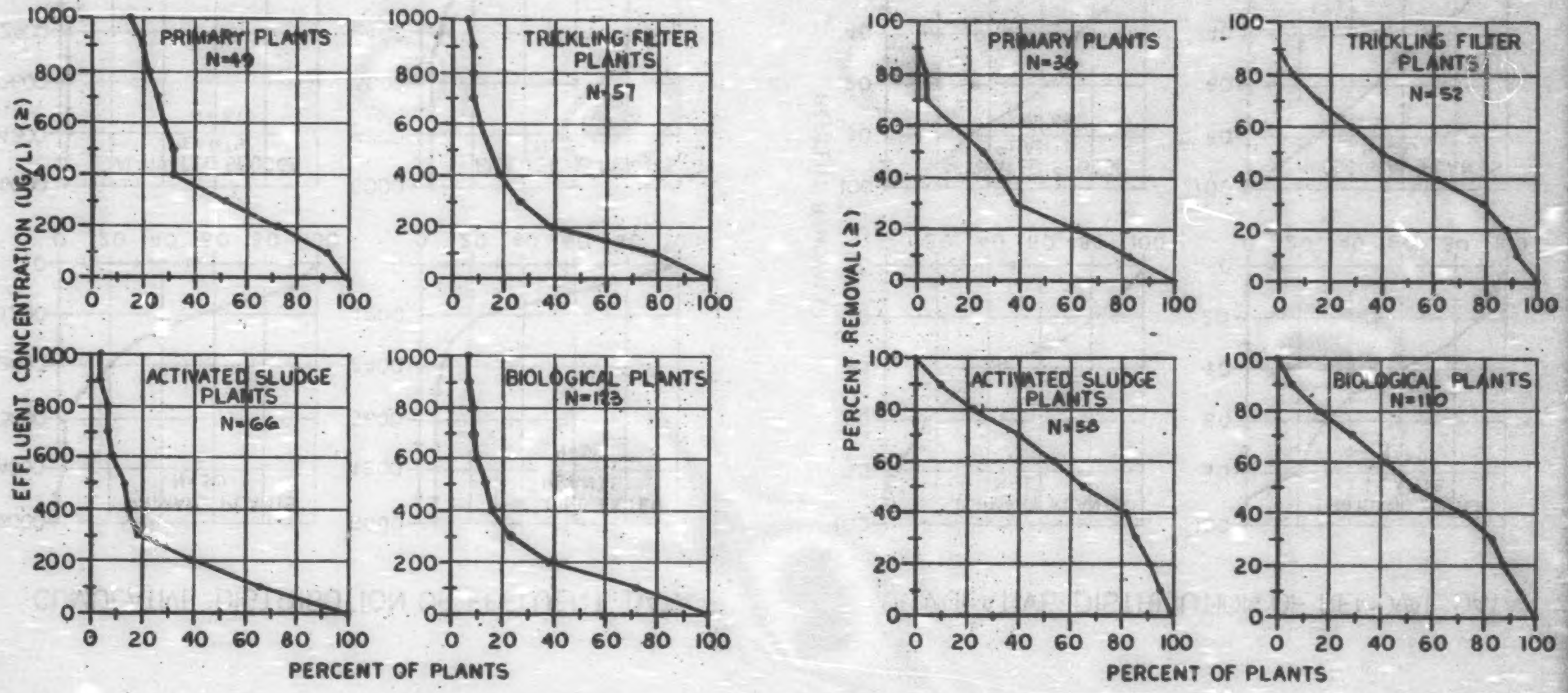


NOTES:-1-"N" IS THE NUMBER OF PLANTS REPORTED
2-"BIOLOGICAL PLANTS" IS THE TOTAL OF TRICKLING FILTER & ACTIVATED SLUDGE PLANTS
3-NICKEL REPORTED AS NI, TOTAL

FIGURE F-7
ZINC

CUMULATIVE DISTRIBUTION OF EFFLUENT DATA

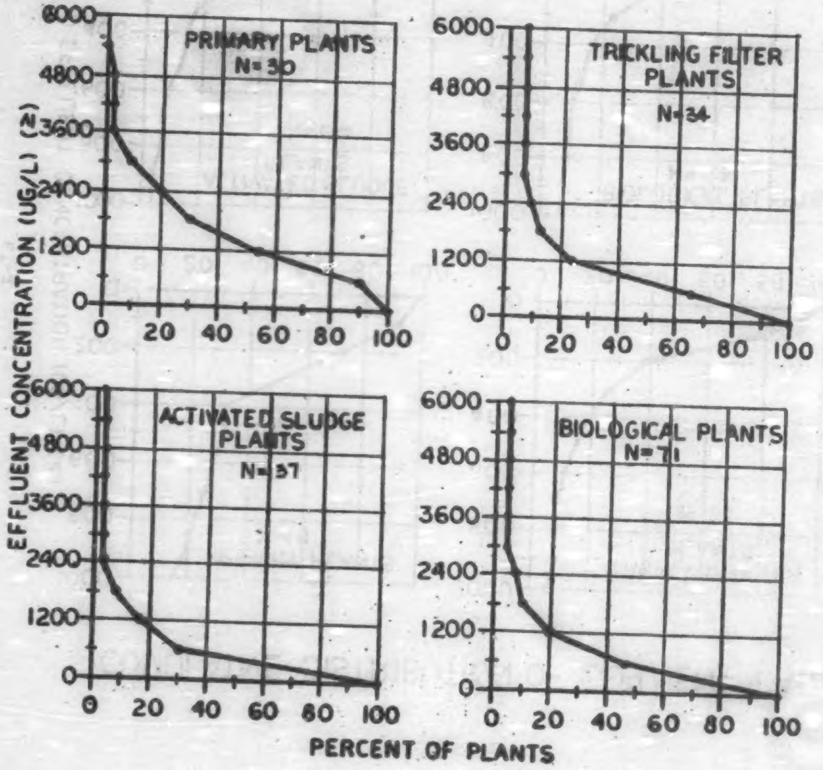
CUMULATIVE DISTRIBUTION OF REMOVAL DATA



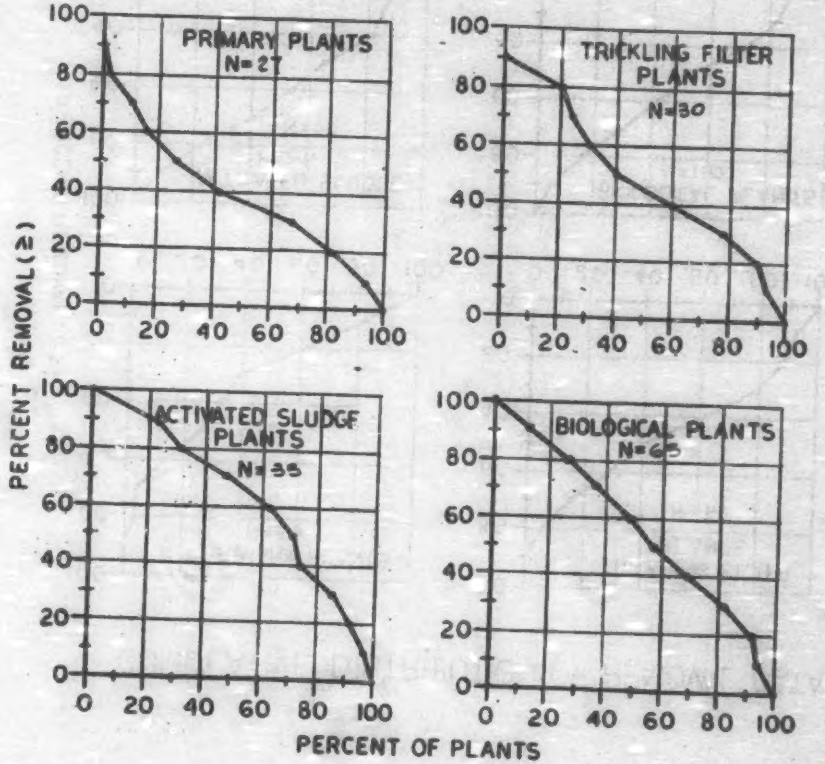
NOTES:-1-"N" IS THE NUMBER OF PLANTS REPORTED
2-"BIOLOGICAL PLANTS" IS THE TOTAL OF TRICKLING FILTER & ACTIVATED SLUDGE PLANTS
3-ZINC REPORTED AS ZN, TOTAL

FIGURE F-8
IRON

CUMULATIVE DISTRIBUTION OF EFFLUENT DATA



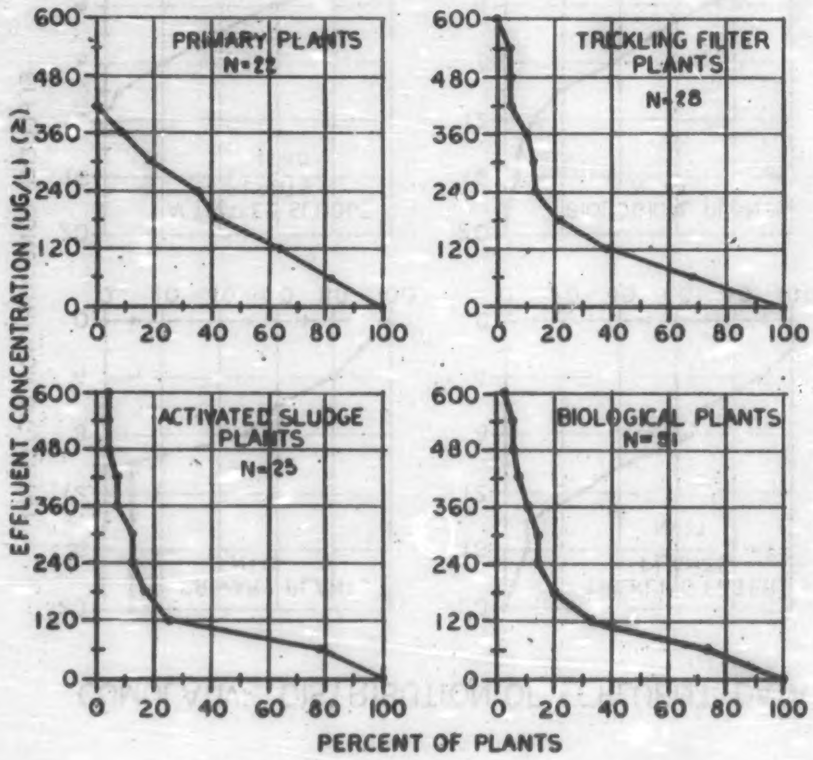
CUMULATIVE DISTRIBUTION OF REMOVAL DATA



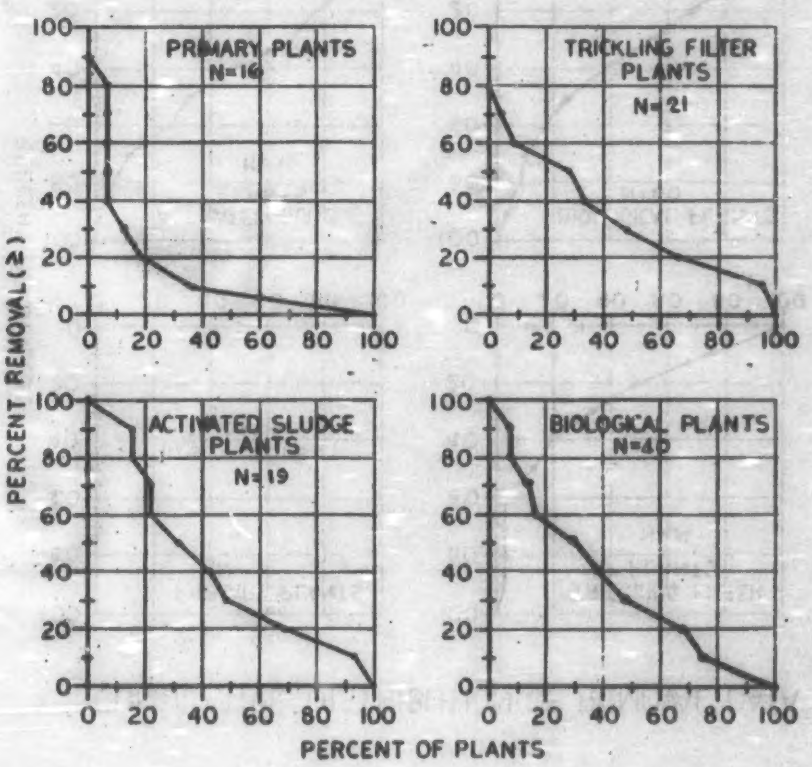
NOTES:- 1-"N" IS THE NUMBER OF PLANTS REPORTED
2-"BIOLOGICAL PLANTS" IS THE TOTAL OF TRICKLING FILTER & ACTIVATED SLUDGE PLANTS
3-IRON REPORTED AS FE, TOTAL

FIGURE F-9
MANGANESE

CUMULATIVE DISTRIBUTION OF EFFLUENT DATA

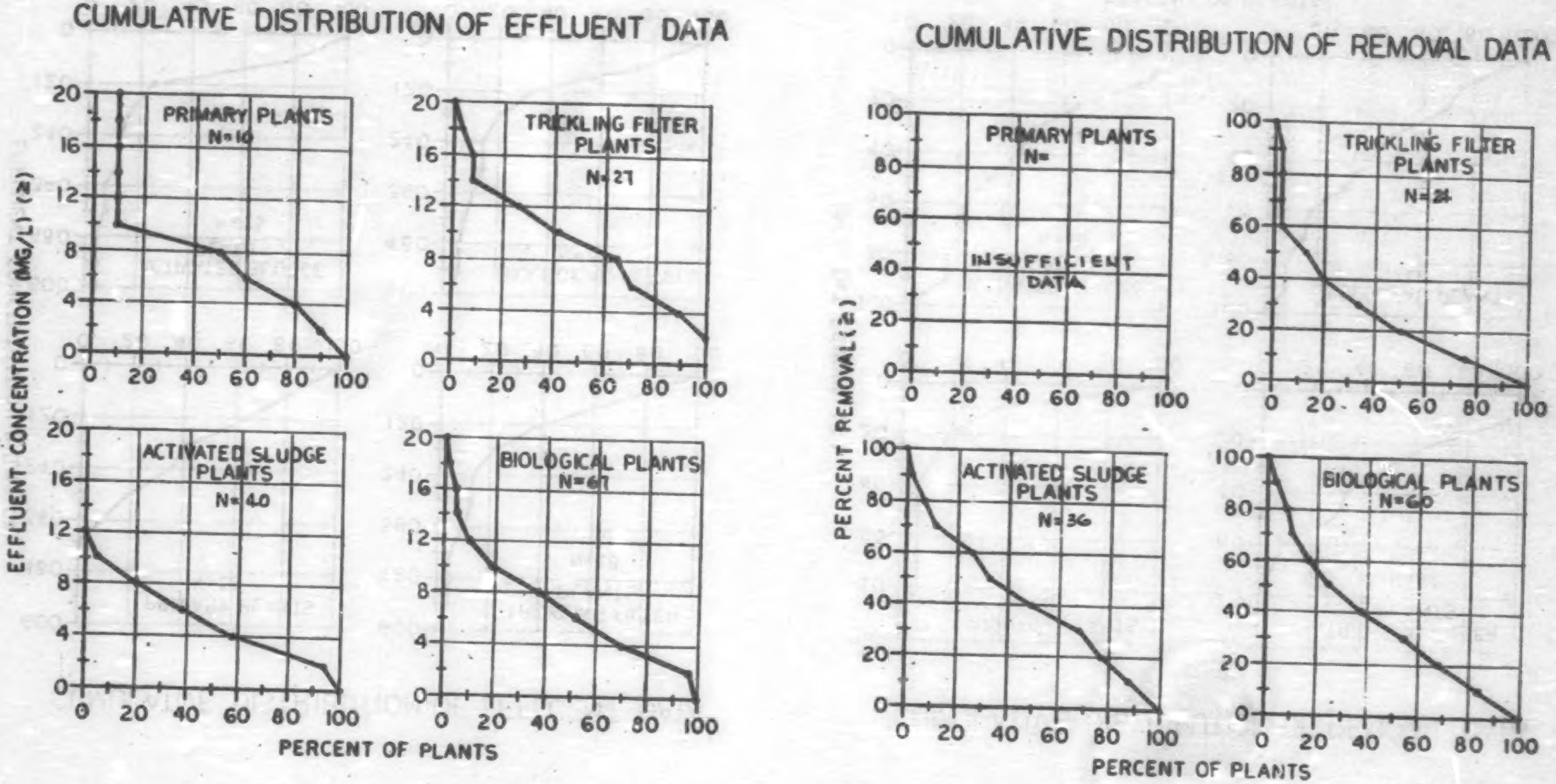


CUMULATIVE DISTRIBUTION OF REMOVAL DATA



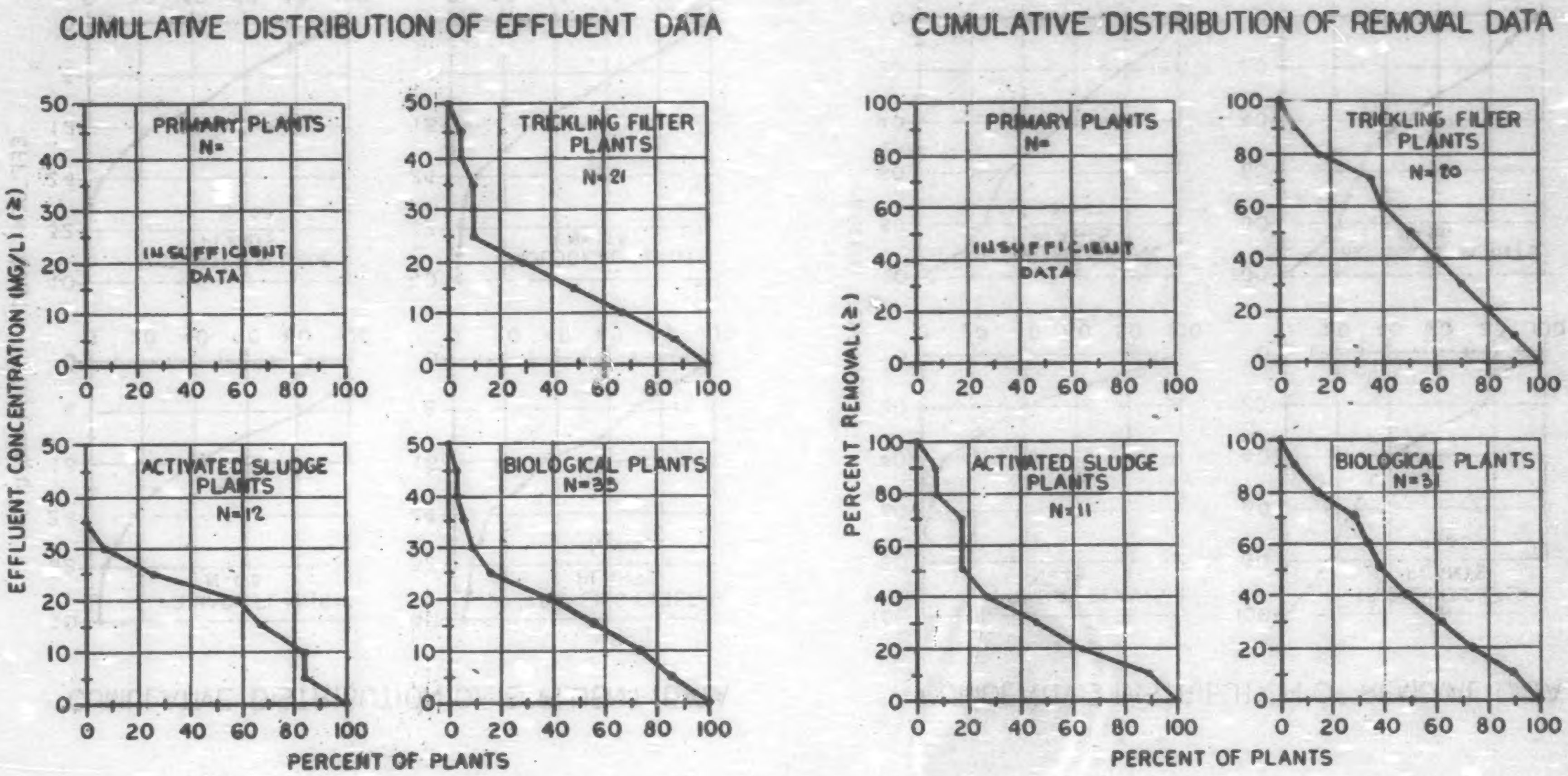
NOTES:- 1-"N" IS THE NUMBER OF PLANTS REPORTED
2-"BIOLOGICAL PLANTS" IS THE TOTAL OF TRICKLING FILTER & ACTIVATED SLUDGE PLANTS
3-MANGANESE REPORTED AS MN, TOTAL

FIGURE F-10
PHOSPHORUS



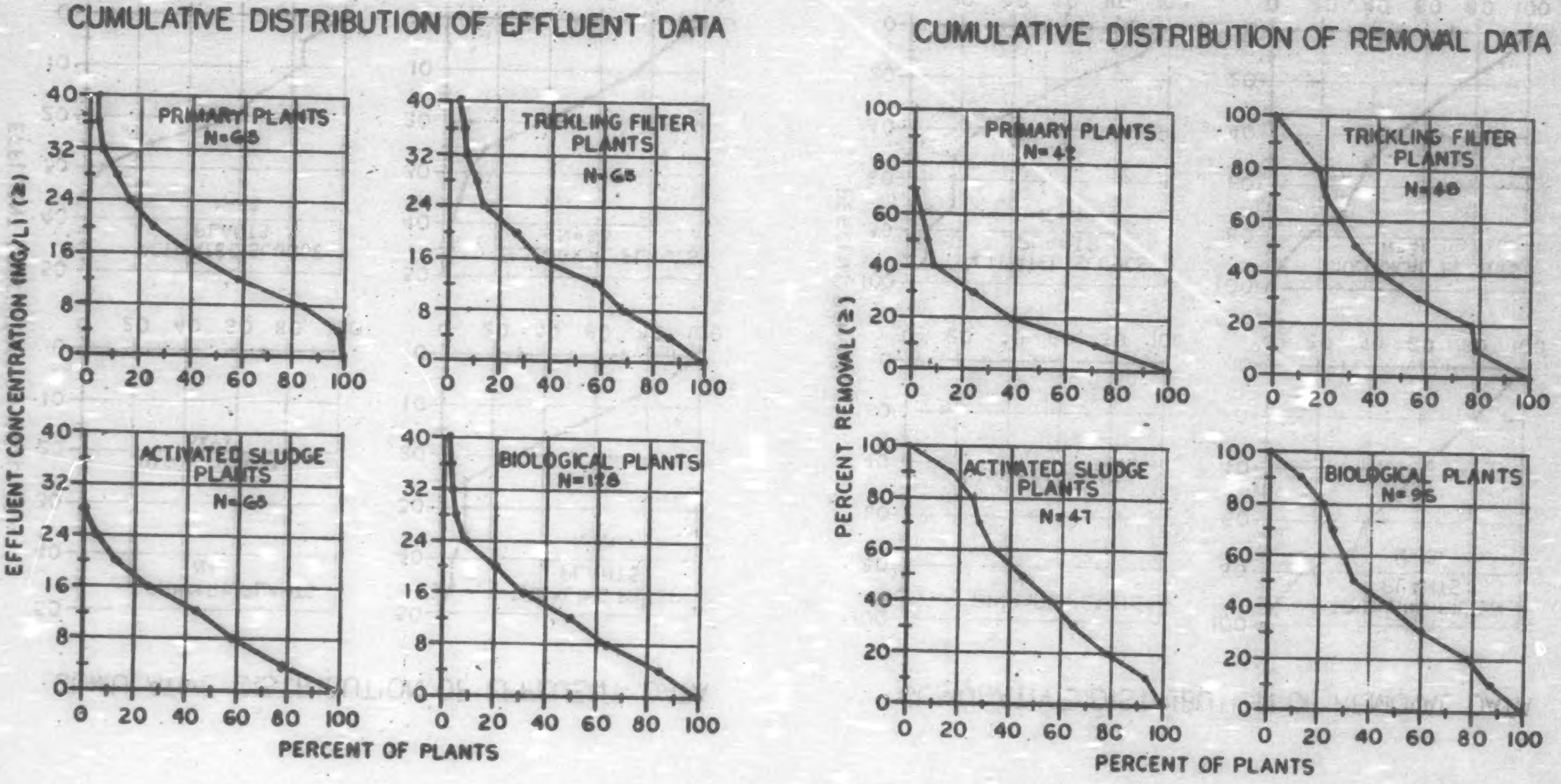
NOTES:-1-"N" IS THE NUMBER OF PLANTS REPORTED
2-"BIOLOGICAL PLANTS" IS THE TOTAL OF TRICKLING FILTER & ACTIVATED SLUDGE PLANTS
3-PHOSPHORUS REPORTED AS P, TOTAL

FIGURE F-11
"KJELDAHL" NITROGEN



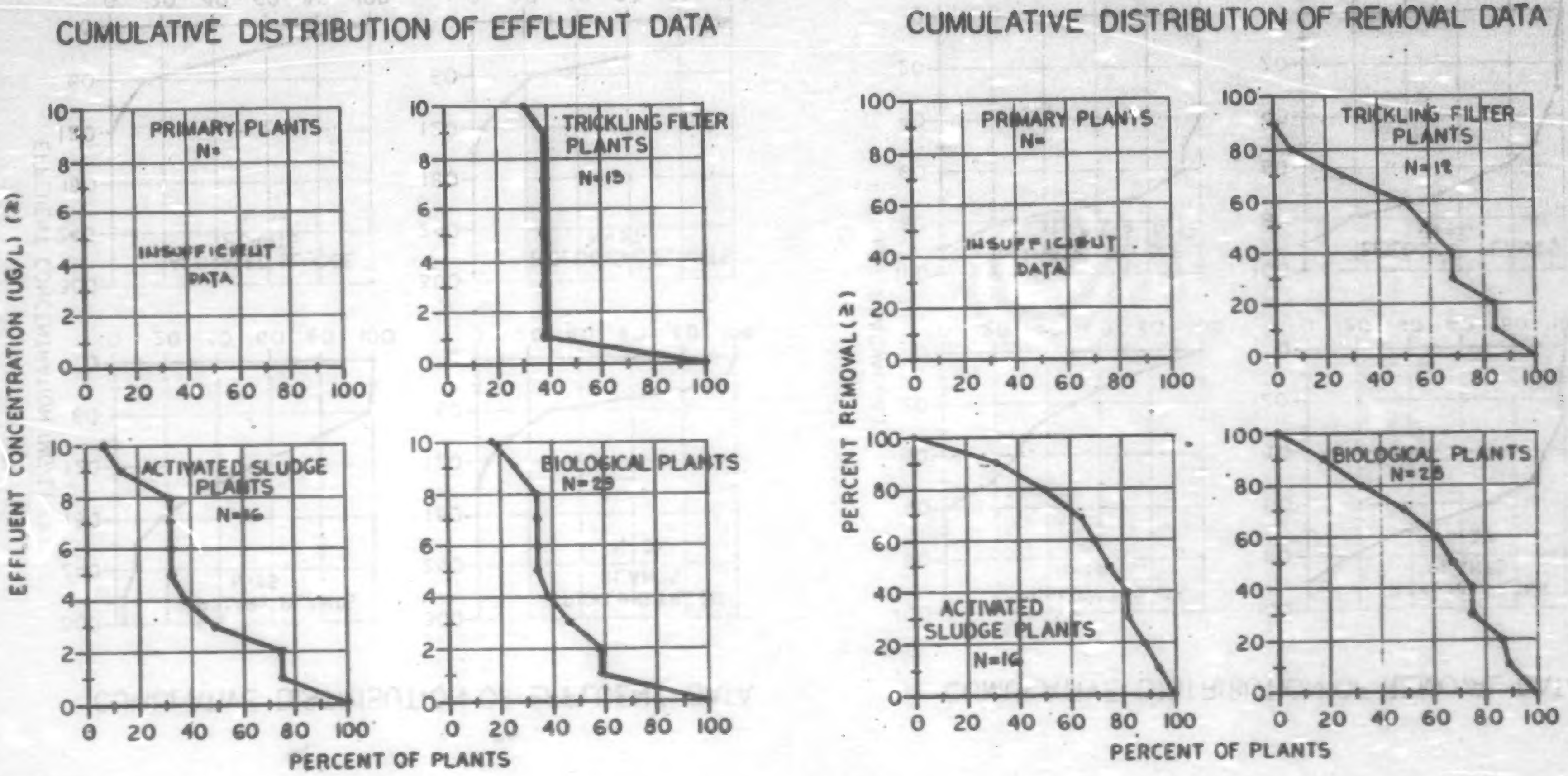
NOTES:-1-"N" IS THE NUMBER OF PLANTS REPORTED
2-"BIOLOGICAL PLANTS" IS THE TOTAL OF TRICKLING FILTER & ACTIVATED SLUDGE PLANTS

FIGURE F-12
AMMONIA



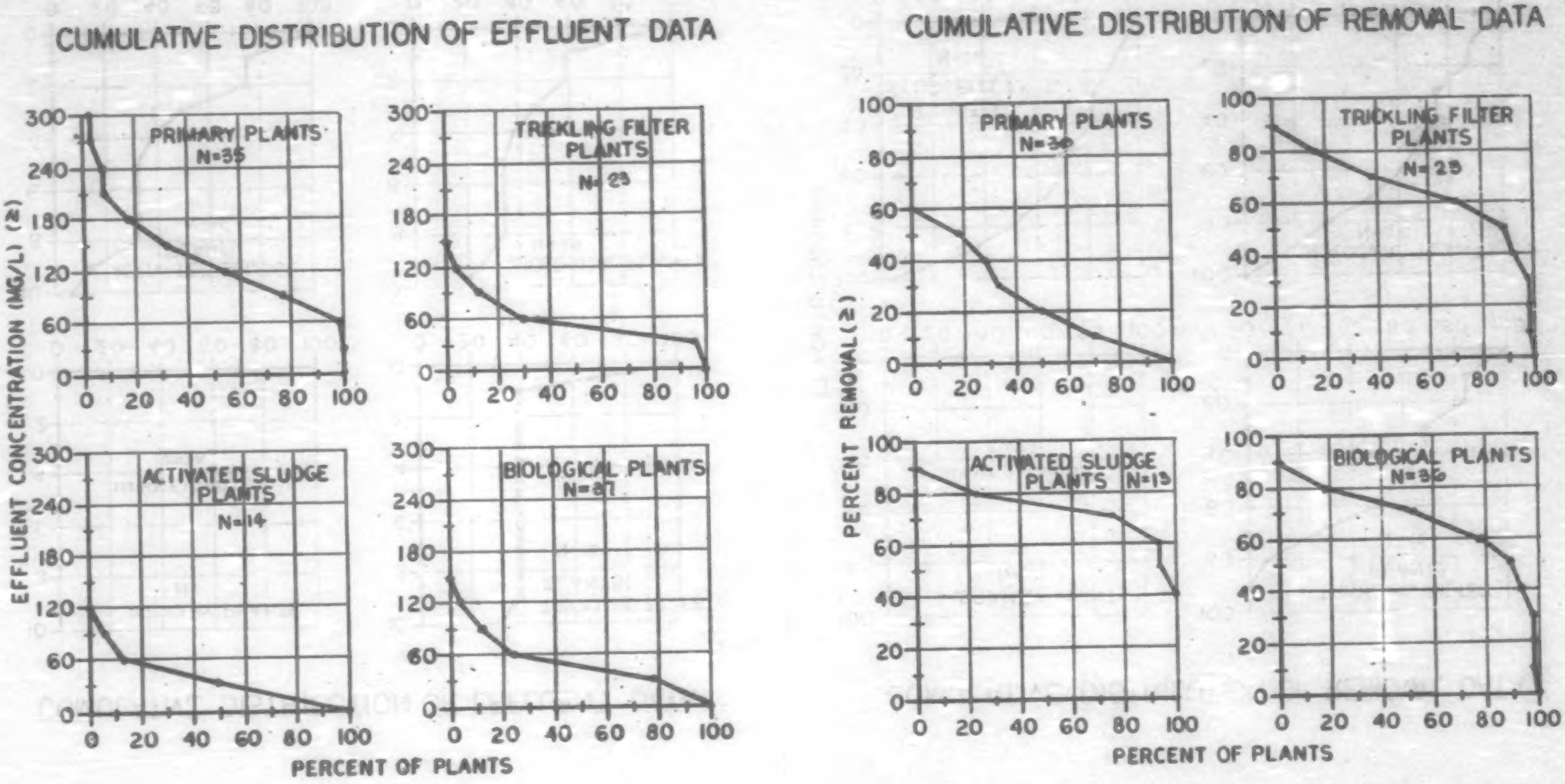
NOTES:-1-"N" IS THE NUMBER OF PLANTS REPORTED
2-"BIOLOGICAL PLANTS" IS THE TOTAL OF TRICKLING FILTER & ACTIVATED SLUDGE PLANTS

FIGURE F-13
PHENOLICS



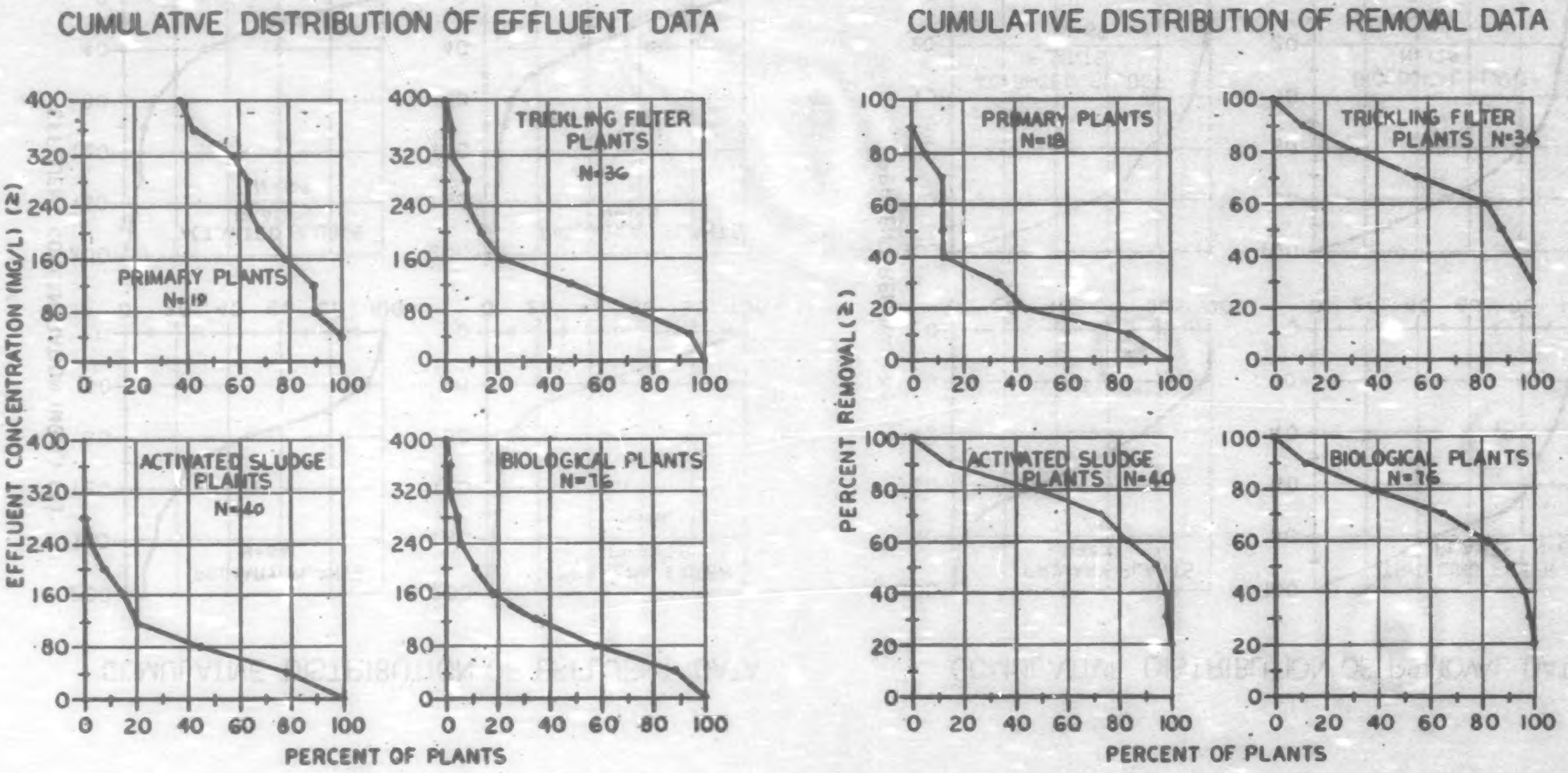
NOTES:- 1-"N" IS THE NUMBER OF PLANTS REPORTED
2-"BIOLOGICAL PLANTS" IS THE TOTAL OF TRICKLING FILTER & ACTIVATED SLUDGE PLANTS

FIGURE F-14
TOTAL ORGANIC CARBON



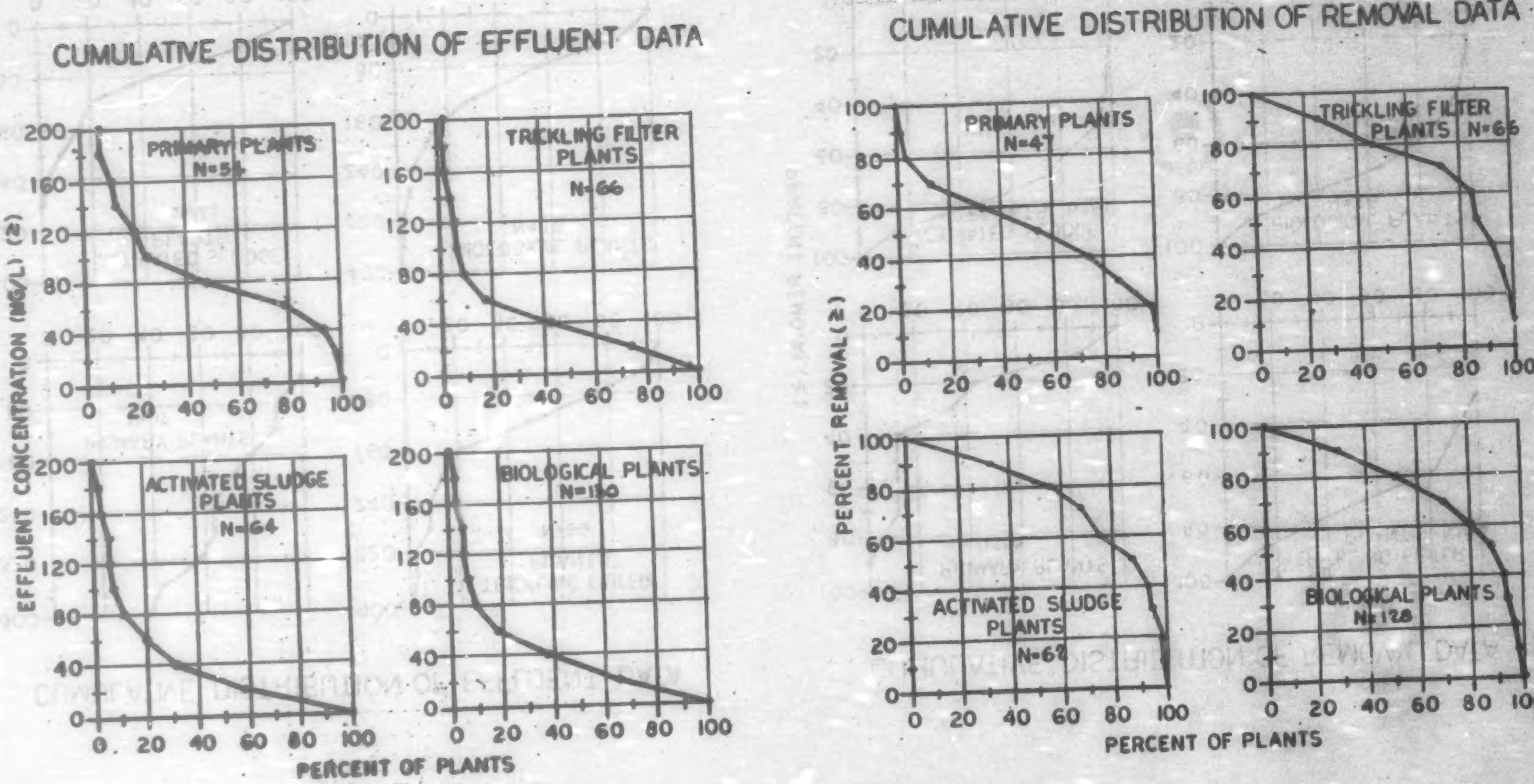
NOTES:-1-"N" IS THE NUMBER OF PLANTS REPORTED
2-"BIOLOGICAL PLANTS" IS THE TOTAL OF TRICKLING FILTER & ACTIVATED SLUDGE PLANTS

FIGURE F-15
CHEMICAL OXYGEN DEMAND



NOTES:-1-"N" IS THE NUMBER OF PLANTS REPORTED
2-"BIOLOGICAL PLANTS" IS THE TOTAL OF TRICKLING FILTER & ACTIVATED SLUDGE PLANTS

FIGURE F-16
SUSPENDED SOLIDS


CUMULATIVE DISTRIBUTION OF EFFLUENT DATA

CUMULATIVE DISTRIBUTION OF REMOVAL DATA

NOTES:-1-"N" IS THE NUMBER OF PLANTS REPORTED
2-"BIOLOGICAL PLANTS" IS THE TOTAL OF TRICKLING FILTER & ACTIVATED SLUDGE PLANTS

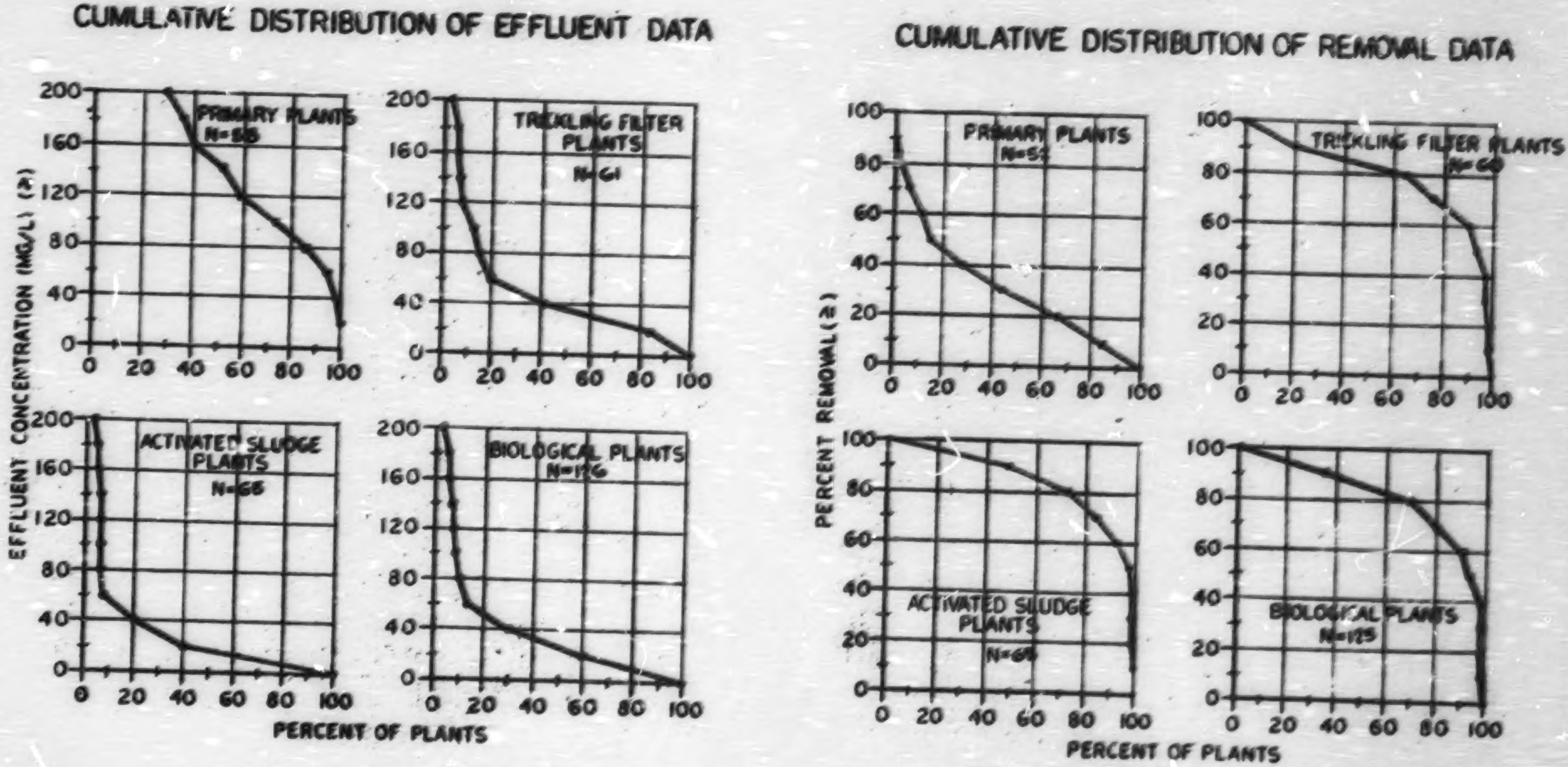


FIGURE F-17
BIOCHEMICAL OXYGEN DEMAND

NOTES:- 1-"N" IS THE NUMBER OF PLANTS REPORTED
2-"BIOLOGICAL PLANTS" IS THE TOTAL OF TRICKLING FILTER & ACTIVATED SLUDGE PLANTS

SECTION G
GLOSSARY

Acclimatization (Acclimation) - A process by which the biological organisms in a biological treatment system develop the capability of maintaining normal life cycles in the presence of concentrations of pollutants that would normally inhibit their activity.

Antagonism - Reduction of the inhibitory effect of one substance by the presence of another.

Compatible Pollutant - A pollutant which is normally treated by conventional biological sewage treatment processes.

Contribution (Contributors) - A point source originating within the area served by a sewerage system and treatment works.

Existing Source - Any wastewater source, which was contributing to a sewerage system, (or a potential source that was under construction), at the time of publication of proposed regulations.

Federal Water Pollution Control Act Amendments of 1972 - Public Law 92-500 which provides the legal authority for current EPA water pollution abatement projects, regulations and policies.

Incompatible Pollutant - Any pollutant which is not normally treated by conventional biological sewage treatment processes.

Industrial Waste Ordinance - An enforceable local law which establishes rules, regulations, limitations and prohibitions to be adhered to by wastewater sources within the service area of a publicly owned sewer system.

Inhibition - A contribution that decreases the pollution removal efficiency of a biological treatment facility.

Interference - A contribution that hinders in any way the operation of a wastewater collection and treatment system. Inhibition can be considered a type of interference.

Joint Treatment - The treatment of a wastewater consisting of a combination of domestic and industrial flows in a single treatment system which has been specifically designed to handle the combined wastewater.

Limited Waste - A waste, which by either local ordinance or Federal regulation, cannot be present in a contribution or direct discharge above a certain concentration.

Major Contributing Industry (MCI) - A major source of industrial wastewater within a POTW system, as defined in the Federal pretreatment standards.

Monitoring - The practice of investigating, surveying and/or sampling wastewater sources in an effort to obtain information on the quality or quantity of the wastewater flow.

National Pollutant Discharge Elimination System (NPDES) - A system of permits to discharge wastewaters to navigable waters developed under the authority of Section 402 of Public Law 92-500. The permit system has as its objectives the achievements of the goal of that law, the elimination of the discharge of pollutants by 1985.

New Source - A wastewater source for which construction began after the publication of proposed regulations.

Pass Through - The discharge to the receiving waters from a publicly owned treatment works of a pollutant without substantial modification or removal.

Pretreatment - The treatment of a wastewater contribution, at the point of origin, prior to release to a publicly owned treatment system.

Prohibited Waste - A material which must be excluded from any discharge of wastewater to a collection system in any concentration. Prohibited wastes include, among others, explosive or corrosive materials.

Publicly Owned Treatment Works (POTW) - A sewerage facility which collects, treats or otherwise disposes of wastewaters, owned and operated by a village, town, county, authority or other public agency.

Synergism - An increase in the inhibitory effect of one substance caused by the presence of another.

Upset - A substantial decrease in the treatment efficiency of a biological treatment system caused by changes in the life cycles of the biological organisms comprising the system.

SECTION H
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